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GUIDELINES ON TRAFFIC MANAGEMENT TECHNIQUES FOR URBAN AREAS

(First Revision)

INDIAN ROADS CONGRESS
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GUIDELINES ON TRAFFIC MANAGEMENT TECHNIQUES FOR URBAN AREAS

INTRODUCTION

The task of revision of IRC:SP:43 "Guidelines on Traffic Management Techniques for Urban Areas" first published in 1994 was entrusted to the H-8 Committee on Urban Roads and Streets. It was recognized that due to fast urbanization, there had been a rapid growth of traffic both motorized and non-motorized. It was, therefore, time to take several measures for the management of traffic so as to reduce congestion on one hand and improve safety of Vulnerable Road Users on the other hand. Balancing of space for both motorized and non-motorized vehicles has become imperative. Several practices around the globe have emerged during the last two decades in this direction. Some of them can be easily adapted in our milieu also.

Accordingly, a subgroup consisting of Dr. Ch. Ravi Sekhar (Chairman), Shri D.P. Gupta, Prof. (Dr.) K.V. Krishna Rao, Dr. S. Velmurugan, Prof. (Dr.) K. Ramachandra Rao, Shri Amit Bhatt, Shri Parin Visariya and Shri Swatantra Kumar was constituted to prepare the draft. The draft prepared by the subgroup was deliberated in a series of meetings of H-8 Committee and was finalized in its meeting held on 27.06.2020.

The composition of the H-8 Committee is given below:

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The revised draft document was placed before the Highways Specifications and Standards Committee (HSS) in its meeting held on 12.09.2020 and continued on 19.09.2020 & 03.10.2020. The HSS Committee decided that the Convenor, H-8 Committee will modify the document based on written and verbal comments offered during the meeting and submit the final document to IRC for placing before the meetings of Executive Committee (EC) and Council. The EC in its meeting held on 18.02.2021 approved the draft document for placing before the Council. The 221st Mid-Term Council in its meeting held on 20th – 21st February, 2021 considered and approved the Draft Revision of IRC:SP:43 "Guidelines on Traffic Management Techniques for Urban Areas" for printing.

SCOPE

The guidelines on Traffic Management Techniques bring out the impact of rapid urbanization and the need for looking beyond the expansion of the highway system. The first recourse is to optimize the existing road space and related facilities to provide improved accessibility and mobility at a satisfactory level of safety and comfort to all road users including pedestrians and cyclists. These guidelines cover various techniques that can be applied to reduce congestion and improve traffic flow on roads in urban areas.

These techniques are discussed in several categories, viz. regulatory, traffic control devices, traffic segregation, transport demand management, bus priority systems, self-enforcing measures, police-public interaction. Brief details on the Intelligent Transport System, Institutional Co-ordination and Citizen Participation are also included as a supplement to the traffic management techniques.

1. IMPACT OF URBANISATION

Rapid industrialization and the consequent urbanization has brought about an unprecedented revolution in the growth of motor vehicles all over the world. Annual Growth Rate (CAGR) of vehicles in India between the year 2007 and 2017 was recorded to be 10.1% (MoRTH, 2017). Among the various category of vehicle, the compound annual growth of 2- wheeler is 10.47%, car is 10.47% and the buses are 3.28% for the same period. During the same time period, the CAGR of the urban population was 2.80%. Thus, evidently, the vehicle population in nation is growing at a much higher rate than the urban population. The combination of rapid motorization, urban sprawl, under-developed road systems, and spatial mismatches has given rise to difficult traffic conditions in cities of the developing world; India is no exception. Today, man and his transport vehicles occupy a large share of the urban space. Traffic congestion, Air and Noise Pollution and the resultant ill-effects and frustrations have become the order of the day. Urban transportation systems are wilting under the pressure of ever growing demands on inadequate street; network, poor non-motorized transport infrastructure, serpentine bus queues; pathetically packed suburban and metro trains and the scarcity of taxis, autos during rush hours underscore the pressure on mass transit system. The traffic problem itself is not new; what is new about it is its growing magnitude and complexity.

As the problems of urbanization and related traffic management have gone through a giant leap. These guidelines has been revised in keeping abreast with these changes. The latest regulatory techniques and traffic control devices like computerised signal control system are included. The propagation of public transit is widely seen as the solution to long term congestion issue in urban transport. Various Indian cities have designed and deployed dedicated bus rapid systems. Keeping this in view, the manual has included a section on bus priority techniques. In the age of information, it is expected of any urban transport system to keep the commuters informed of the current state of traffic, real time information on public transport. Variable message signs play a major role in the dissemination of both static and dynamic information to the travelers for a better and seamless travelling experience. Thus, a special section on public interaction technique has been added that focuses on the use of variable message signs for the aforementioned purpose. Apart from these, sections on different policy approaches have been covered. These wide policies range from odd-even policy, congestion pricing schemes, and different parking management schemes like park and ride.

The objective is to make these guidelines comprehensive and inclusive of best practices for traffic management and improvement of traffic flow in the urban context.

2. IMPORTANCE OF TRAFFIC MANAGEMENT

Traffic is generally defined as the movement of people, goods or vehicles between spatially separated points, and thus includes pedestrians and all types of vehicles mechanised, motorised or non-motorised. Traffic planning must, therefore, look beyond the expansion of the highway system, and deliberate on the principles of demand and supply so as to use the available infrastructure optimally. Traffic management is the application of sound management principles and practices to optimise the use of the existing road network with a view to improving traffic flow and road safety without impairing environmental quality and equitable mobility for all road users.

The only recourse open to the traffic manager, therefore is the option of optimising existing road space and related facilities to provide improved accessibility and mobility at a satisfactory level of safety and comfort to all road users. This can be achieved after studying and evaluating the problems in the light of sound and tested traffic management techniques, which are implementable and flexible. These are short term solutions, primarily intended to reduce the intensity of inconvenience caused by congestion and the multiplicity of the modes of transport conflictingly trying for the same space. They may not offer a permanent solution, yet they lend themselves to sometime earning relief up to a point where the administration may launch a long term solution. It is, of course, absolutely imperative to integrate the long term and short term planning. The objectives of the short term solutions should be within the perspective, and be compatible with the goals set out in the long term plans.

The traffic management techniques that have been practiced in varying degrees all over the world have been listed below under seven main categories:

(i) Regulatory Techniques

- One-way Streets
- Reversible Streets
- Reversible Lanes
- Turning Movement Restrictions
- Closing Side-Streets
- Bus and Non-Motorized Transport Only Street

(ii) Traffic Control Devices

- Traffic Signs
- Road Markings
- Traffic Signals
- Computerised Signal Control System
- Traffic Cones and Drums
- Barricades
- Traffic Calming Measures
- Traffic Lighted Bollards

- Central Refuges
- Compact Intersection
- Intersection Channelization
- Automated Traffic Violation System (red-light jumping, over-speeding)

(iii) Traffic Segregation Techniques

- Pedestrian Malls
- Sidewalks
- Central Medians
- Central Railings
- Creation of Storage Lanes at Turning Points
- Bus Bays on High-Speed Corridors and Arterial Roads with Adequate Right of Way Width
- Bicycle Lanes Segregated Cycle Track
- Off-Street Loading/Unloading Facilities
- Consistent Carriageway Width
- Pedestrian Grade-Separation at High-Speed Corridors

(iv) Parking Policies

- Parking Restrictions
- On-Street and Off-Street Parking Supply Reduction
- Parking Pricing
- Preferential Parking for High - Occupancy and Space-Efficient Vehicles

(v) Demand Management Techniques

- Staggered Work Time
- Preferential Lanes for High ~ Occupancy and Space Efficient Vehicles
- Road and Bridge Tolls
- Supplementary Licensing
- Area Tolls
- Vehicle Ownership Taxation
- General Fare Reduction on Public Transport
- Robust and Continuous Network of Walking and Cycling
- Introduction of the Concept of Living Streets

(vi) Bus Priority Techniques

- Priority Manoeuvres
- Median Bus Lanes
- Bus-Precincts

- Bus Priority Signal Systems
- Bus Operations Management

(vii) Self-Enforcing Techniques

- Dividers
- Railings
- Channelisers
- Queue Channels
- Parking Notches
- Sleeping Policeman
- Bus Bays
- Sharing of Taxis
- Fixed Taxi Tariff System

(viii) Police-Public Interaction Techniques

- Education to bring about Traffic Awareness
- System-Condition Broadcasts
- Traffic Booths for and of Road Users
- Stringent Laws for not allowing the Private Vehicles to Dedicated Bus Lane

3. NEED FOR SYSTEMS APPROACH

Though the identification of the problems and proper diagnosis may automatically suggest the usefulness of a particular management technique, the application of a single technique, in isolation, is rarely sufficient in bringing about a significant improvement in the level of service and transportation mobility of an area. More often than not, the problems shift to the adjacent locality, or an entirely new problem is spawned as a consequence of the very technique used as a solution if applied in isolation. It is, therefore, essential to seek solutions in a combination of techniques, even in a relatively local situation, for effective management. A solution must be observed as a part of the total scenario and the systems approach used to prepare a Traffic System Management (TSM) Plan for the entire network.

3.1 Selection of Proper Technique(s)

Every city has a traffic complexion of its own, nurtured by its own characteristics. Therefore, it is not wise to import a technique and apply it blindly in a town, merely because it was a success elsewhere. It is necessary to study the areas and sub-areas and accord proper and appropriate priorities depending upon the objectives to be achieved. Different sub-areas/corridors require different treatments depending on the nature of the problems and priority objectives. After examining the overall transport vision of the city, funding position and the constraints, in situ,

various sub-areas plans can be prepared and mutually integrated to form the program package. This process presupposes a thorough knowledge of the independent impacts of the TSM actions as well as their interactions. Several TSM actions can have the desired effect when applied in many similar locations, while there are others that call for related and coordinated actions for each separate application. Specific TSM actions may have a positive impact in one corridor, but may adversely affect another. Therefore, the selection of TSM tools and the study of their combinatory effect is significant, and should never be under emphasised.

3.2 Community Involvement

It must also be understood that public participation and cooperation are essential pre-requisites for the success of TSM programmes, especially in a developing country like India, where diversity of social customs and prejudices abounds. Traffic management and community involvement are two sides of the same coin and are not mutually exclusive.

Any attempt to bypass the community would prove counterproductive in the long run, and no major scheme will be able to survive for a long time. The traffic management plan should be administratively sound, politically tolerated, and socially acceptable. All efforts should be made to involve people. They should be given prior details of the proposal(s) through print/audio/video media and their comments/views invited.

4. REGULATORY TECHNIQUES

Regulatory techniques are the most common and straight forward techniques. The following techniques may be adopted:

- Bus and Non-Motorised Transport only Streets
- One-Way Street
- Reversible Street
- Reversible Lane
- Turning Movement Restrictions
- Closing Streets

4.1 One-Way Street

One-way streets are those where the vehicle movement is permitted in only one direction. They help in optimising the road capacity and minimising conflicts, which ultimately result in better traffic flow. It also simplifies traffic operations at intersections and reduces delays to moving traffic. A typical layout of the One-Way Street operation is shown in **Fig. 4.1**. If proper enforcement is not there, some time this one way streets encourage on-street parking.

The following points need careful consideration before the implementation of the one-way street system:

(i) The one-way system is best suited for the network that has a grid pattern i.e. availability of parallel roads with evenly spaced crossroads connecting them. The distance between such complementary streets should not normally exceed 300 meters. In the absence of parallel streets, the travel distances may increase substantially and lead to wrong side driving, especially by two-wheelers.

(ii) Unless complementary roads with reasonably parallel alignment are available, a one-way system should not be normally resorted to. As a rule of thumb, it is desirable to ensure that the extra travel distance resulting from the one-way system does not usually exceed 30 percent of the original.

(iii) The complementary streets so chosen should not have mixed land use.

(iv) Proper care should be taken to study the pattern of the displaced traffic (as a result of the one-way system) as it would have a tendency to resort to rat-runs through residential areas in order to avoid the longer detour. In such situations, sufficient speed breakers/barriers should be installed in the residential area to discourage such short cuts. Streets should provide safe pedestrian crossings at intersections and midblock. Signalized crossings should be provided at intersections. In no case, the carriageway should have more than three lanes.

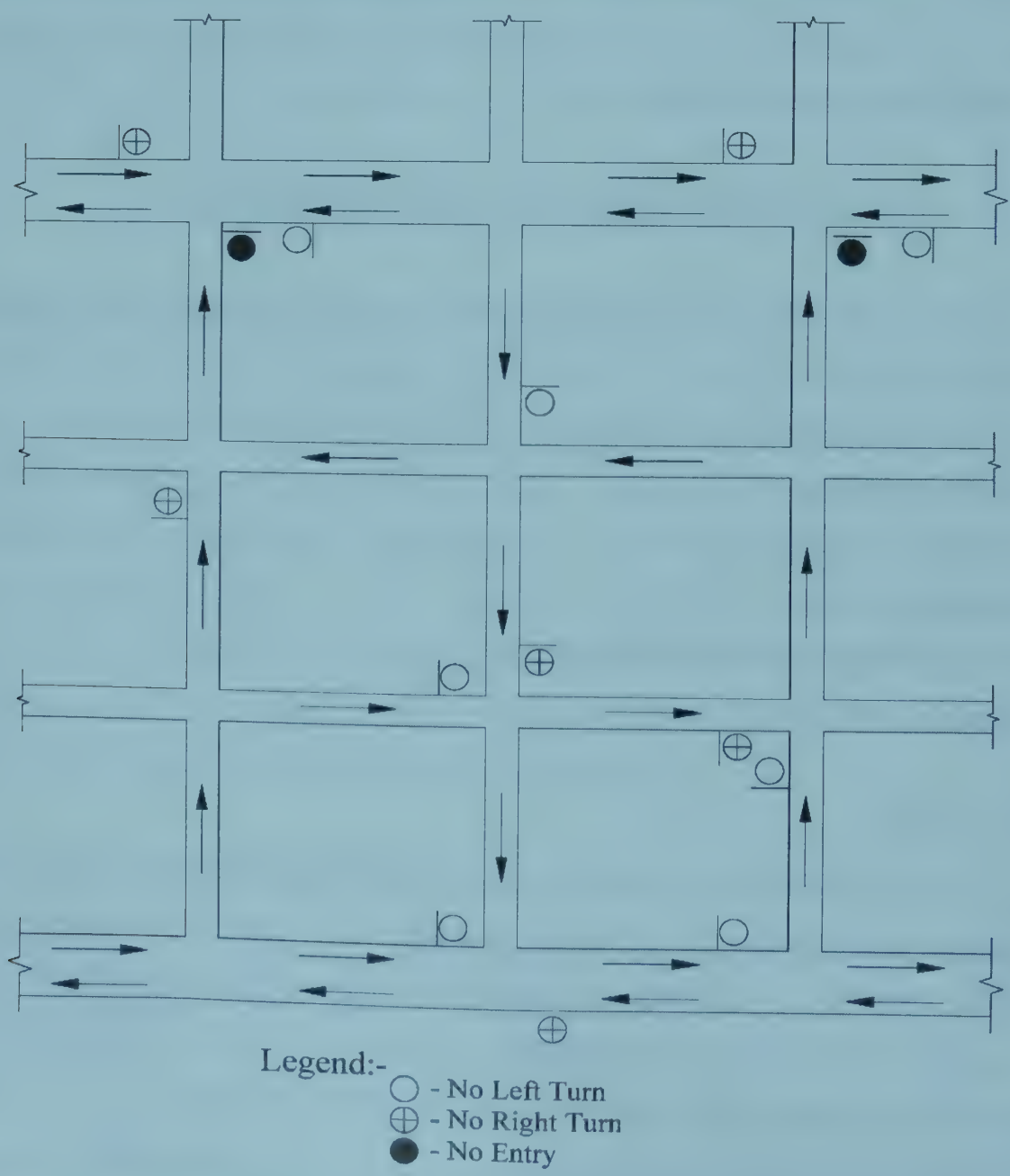


Fig. 4.1 Typical Layout of One-Way Street System

(v) Abrupt ending of one-way street should be avoided. If necessary, the one-way system can be extended beyond the earlier intended point. The adjacent areas, where the displaced traffic is likely to have implications, should also be studied in conjunction with the area under consideration.

(vi) As far as possible, a particular street should be continued one-way in the same direction, end to end, except under particular circumstances.

(vii) Good signage and lane markings are the main pro-requisites of any one-way system. “No Entry”, “One-Way” and ”No Right/Left Turn” signs should be conspicuously displayed at all strategic points, especially at the ends of the one-way street and at the meeting points of the crossroads.

(viii) It is always desirable to consider a one-way system with other management techniques such as parking restrictions, loading and unloading restrictions, progressive signal system, locations of the bus stops, contra-flow bus lane, etc. Area level on-street parking and freight management plan is required for the successful implementation of the one-way street system.

(ix) It is very essential to give adequate publicity well before the introduction of the one-way system by distributing leaflets, publicity through press, posters at strategic places, etc. giving clear cut details of the proposed circulation system. During the experimental stage, a number of police personnel should be detailed at strategic places to politely guide the users who might get confused in the initial stage.

(x) As far as possible, the one-way system should always experimented on Fridays so that whatever confusion is witnessed on the first day can be corrected during the next two days which are lean traffic days.

4.2 Reversible Streets

This technique is useful in situations having uni-directional peak traffic patterns so that an important street is made one-way in the peak direction in the morning and vice-versa in the evening with a view to optimising the flow of traffic during peak-time.

(i) This technique is, however, useful only if there is another parallel street available in close proximity to accommodate the opposite traffic.

(ii) The reversible one-way system is advantageous only if the volume of traffic in the peak direction is near twice the one moving in the lean direction.

(iii) It is preferable to control the operation of a reversible street with the help of a traffic signal. The Green signal indicates the direction of flow, as per the time plan, and prevents accidents. The direction change over time is the most crucial period. It would be, therefore, advisable to post a traffic constable during the transition period.

(iv) An adequate number of signs should be conspicuously displayed, indicating the correct direction and time.

(v) The reversible street should be retained one-way even during the night in the same direction as in the evening. Too many directional changes are not desirable.

(vi) Adequate publicity is essential to make the public aware of the direction and time of operation.

4.3 Reversible Lane

This technique ensures the apportioning of the carriageway between two directions of travel in a manner that matches the volume of traffic. Additional lane(s) can be allotted to the peak flow direction by squeezing the width of the carriageway meant for the opposite traffic so as to optimize the utilisation of road space. A typical reversible lane is shown in **Fig. 4.2**.

(i) This technique should normally not be implemented unless the total width of the carriageway is more than three or more lanes; since on narrower roads, snatching of a lane would leave very little space for the lean direction flow that can cause serious bottlenecks in case of an accident, or breakdown, or halting of a bus at a stop.

(ii) Traffic cones should be used to delineate boundary of the additional area taken away from the opposite carriageway.

(iii) Signs showing the direction should be conspicuously displayed at both ends of the lane.

(iv) Traffic constables may be deployed at both ends of the street so as to ensure that a new driver to the city does not enter the wrong lanes.

(v) At pedestrian crossings along the section of the operative lane, policemen should be deployed so as to prevent accidents and help safe crossing. The reversible lane should be painted continuous white with arrows showing both directions.

(vi) Proper care should be taken for bus stops and cross movements and traffic from side streets.

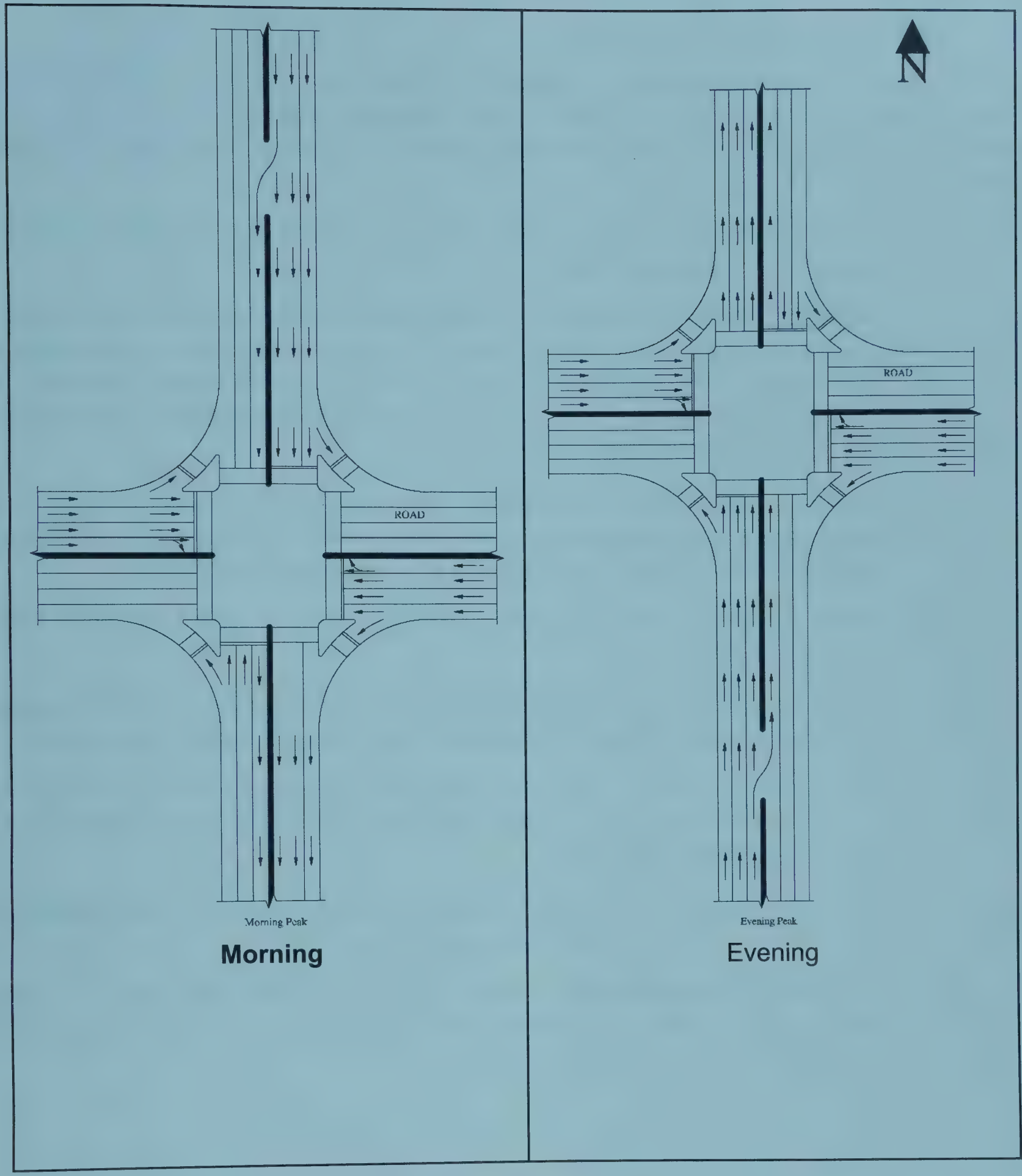


Fig. 4.2 Reversible Lane

4.4 Turning Movement Restrictions

Ban on turning movements minimises conflicts at intersections, thus enhancing their capacity as well as safety. It also simplifies the traffic signal phases to minimise delays at the crowded intersections. It is essential to consider alternative routes for diverting the affected traffic before banning any turn.

(i) Left turns are rarely banned unless an intersection has multiple arms or pedestrian flow across the street is heavy.

(ii) As far as possible, free left turn at a signalised intersection should be avoided. If, at all, it has to be given, 'blinking amber' and appropriate traffic calming measure aspect must be incorporated to caution motorists to slow down. Cautionary sign indicating "free left turn" should also be conspicuously displayed for warning both the drivers and the pedestrians.

(iii) If there are two similar intersections at close distance on a major corridor, it shall be prudent to ban complementary turns at adjacent intersections so as to stagger the traffic load uniformly and minimize inconvenience to motorists.

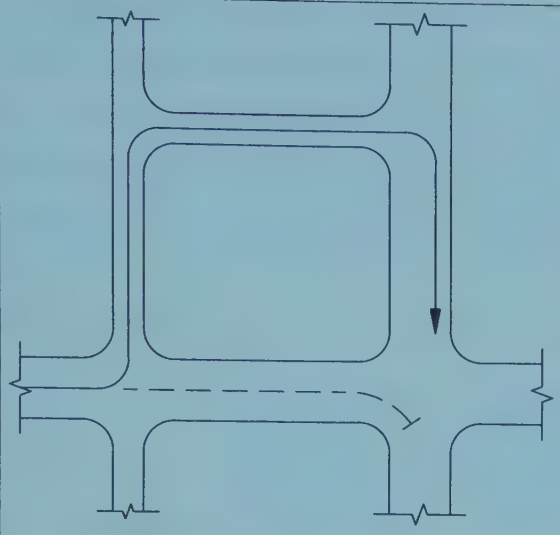
(iv) There are three commonly used procedures through which the right turning, traffic can be re-routed:

(a) Diversion of the right turning movement to the left, before the congested intersection is what is known as G-turn and illustrated in **Fig. 4.3(a)**.

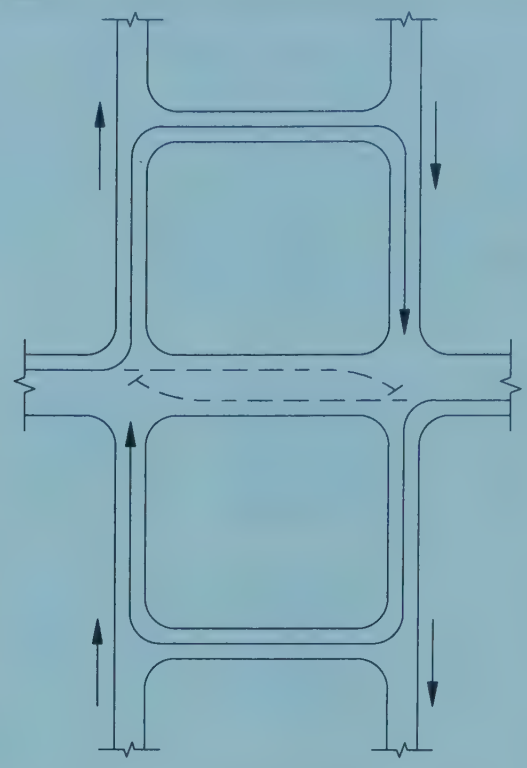
(b) Diversion further along the road, so that the difficult right turnings from a minor road onto a major road take place at a minor intersection, as indicated in **Fig. 4.3(b)**.

(c) Diversion to the left beyond the intersection, requiring three left turns. This is known as Q-turn and illustrated in **Fig. 4.3(c)**.

(v) It is always desirable to ban U-turn, wherever possible, particularly on a major artery, a busy street, or a narrow road where geometrics and the road width do not permit U-turn in one manoeuvre.

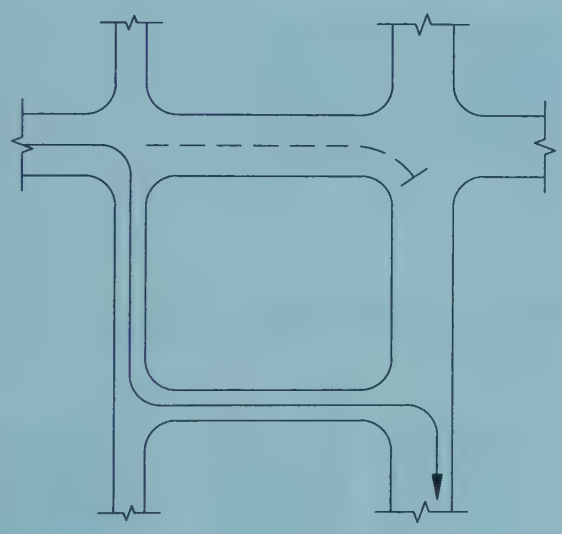


1. Left Turn Before Reaching Intersection

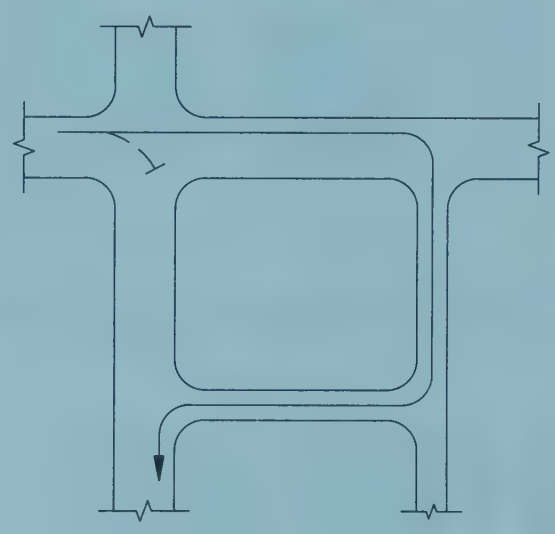


2. As 1.But Where One Way Roads Cross a Main Road

(a) G- Turn

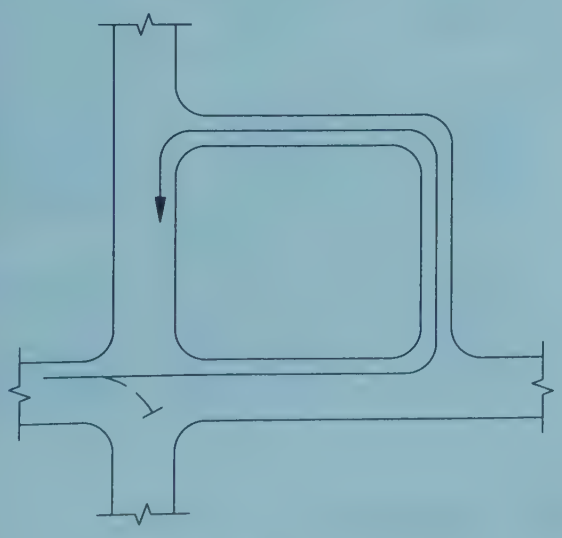


3. By a Right Turn Before Reaching Intersection

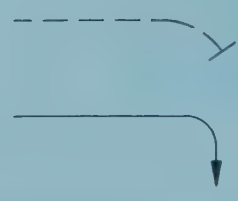


4. By a Right Turn After Reaching Intersection

(b) T- Turn



5. By Three Left Turn After Passing An Intersection



Denote Denied Route

Denote Alternative Route

(c) Q- Turn

Fig. 4.3 Re-Routing Right-Turning Traffic

In order to reduce intersection delay along with a Bus Rapid Transit (BRT) corridor, intersections can be simplified by prohibiting right turns across the BRT corridor **(Fig. 4.4)**. Vehicles can still make the right turn at the circled junction by turning left three times and then crossing perpendicular to the corridor. In the left diagram, the right turn can be accomplished by turning left, followed by a U-turn. In right diagram, vehicles make two right turns at less critical junctions away from the BRT corridor **(Fig. 4.5)**

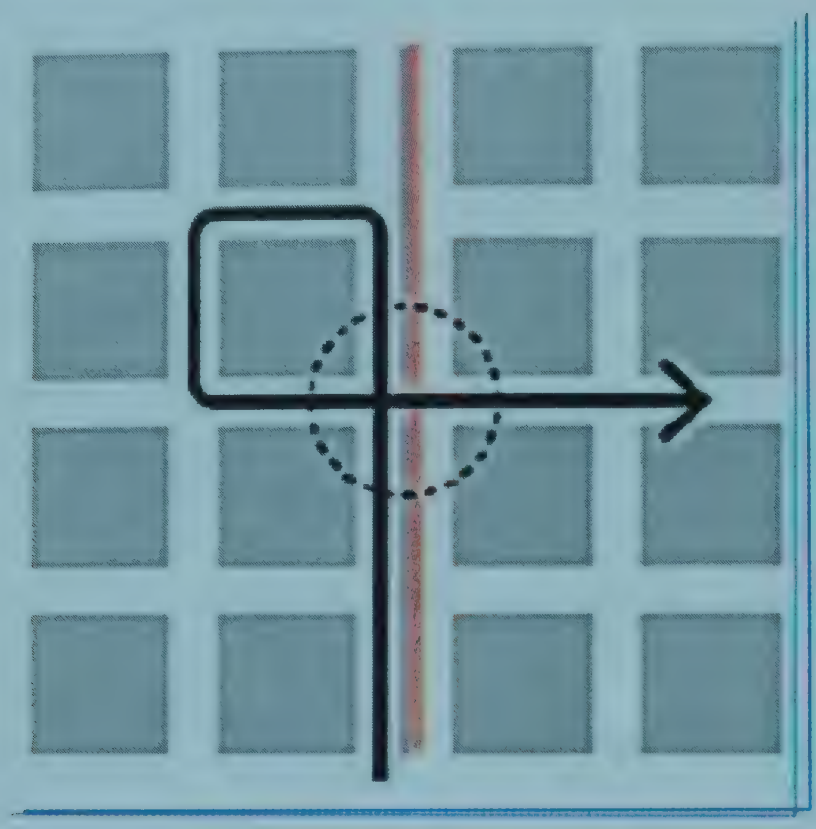


Fig. 4.4 Right Turning Prohibition at BRT Crossings

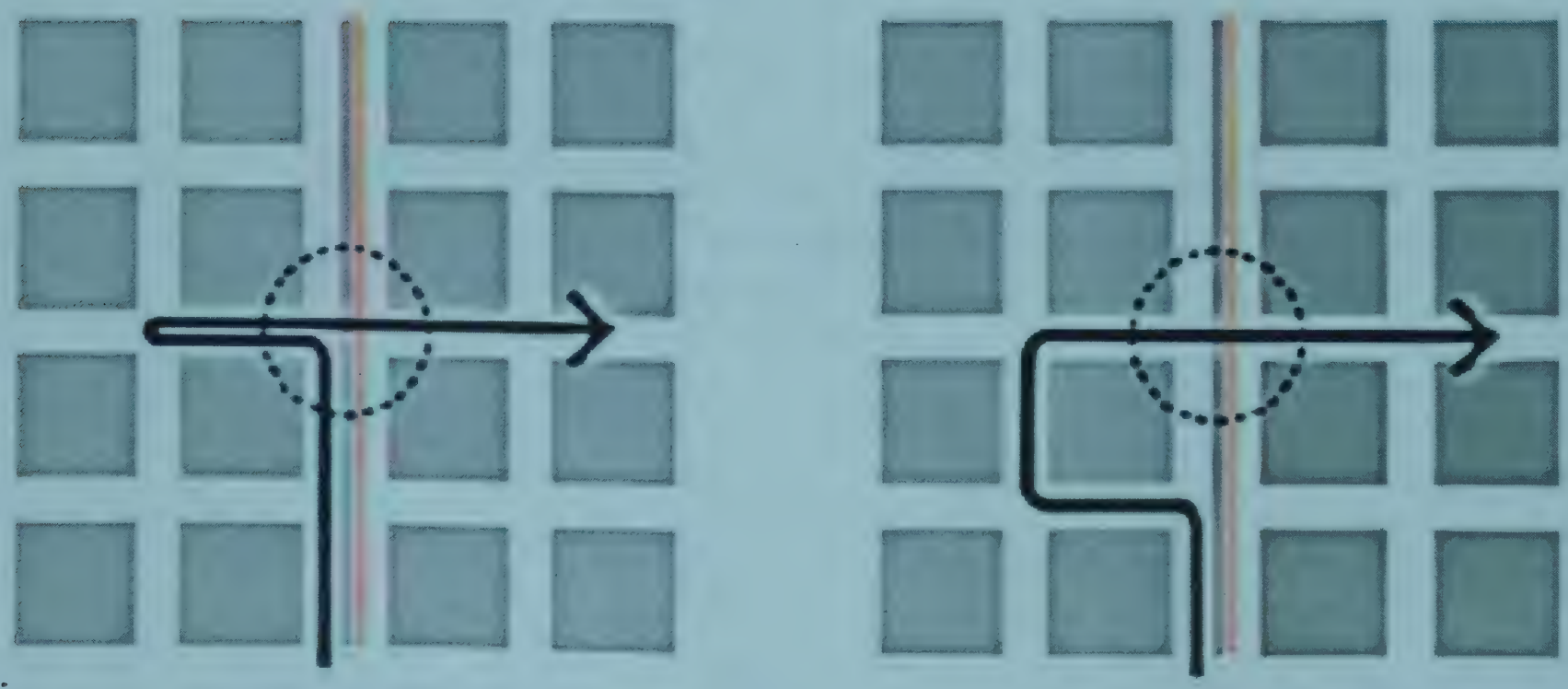


Fig. 4.5 Turning at BRT Crossings

4.5 Closing Side-Streets

This technique envisages closure of side-street with a view to improving flow on the main street by minimising conflicts. It naturally enhances the safety level as well. It helps in staggering the load at the complicated intersection, besides reducing enforcement burden and even need for a signal. If there is a parking demand in such an area, the side lanes can be gainfully used; however, in that case, parking on the major street must be banned to improve its capacity. In the shopping areas, such cul-de-sac streets can be converted into pedestrian plazas.

However, if a side street is to be closed in an area where easy access is not available nearby, it would be better to close the streets with a chain instead of using permanent physical barrier so that access to emergency vehicles is available during any exigency, **Fig. 4.6**.

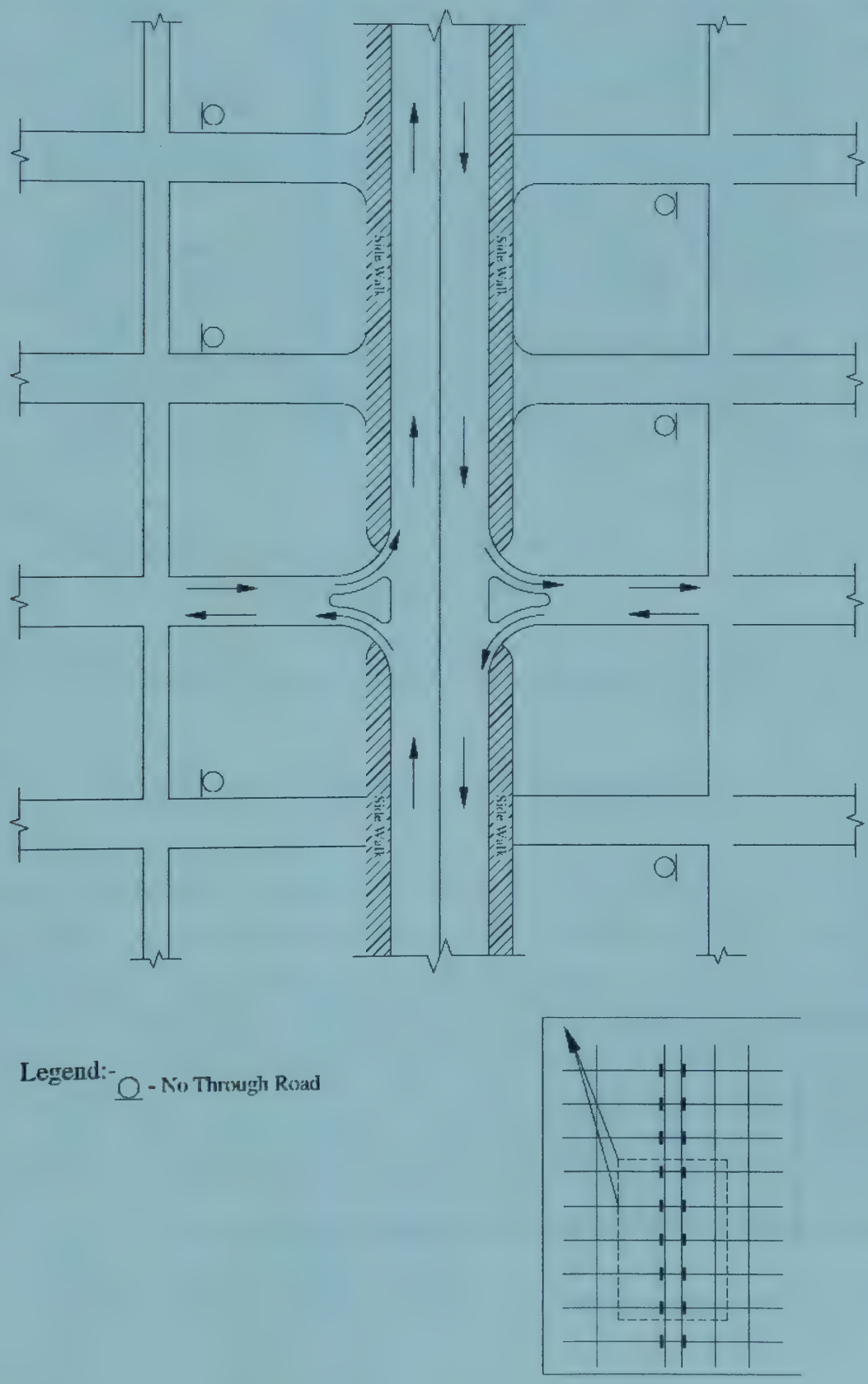


Fig. 4.6 Closing Side Streets

In Barcelona city core, presently, a collector road network creates block sizes of 100 m x 100 m. The superblock grid allows pedestrians and cyclists to pass through the neighborhood, whereas vehicles can only access properties, but movement is not permitted. An example of Barcelona's superblock planning is presented in **Fig. 4.7.**

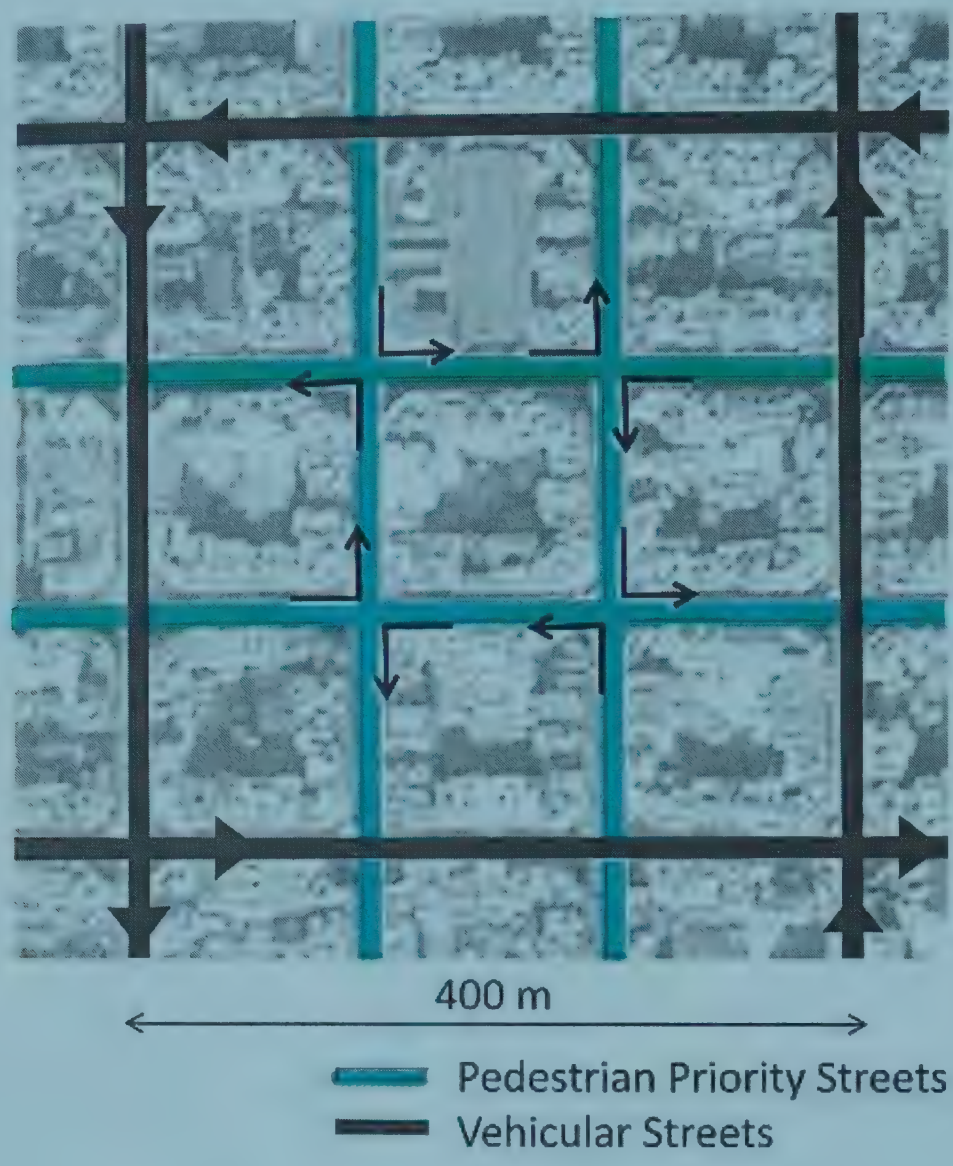


Fig. 4.7 Barcelona's Superblock Planning

5. TRAFFIC CONTROL DEVICES

Traffic control devices are signs, signals, pavement markings, flashers, barriers, delineators and other devices placed on, over, or adjacent to a street, expressways, highways, cycle tracks and footpaths to enable vehicles and pedestrians to move safely and efficiently. These devices are placed (by the authority of a public body or official having jurisdiction) in key locations to guide traffic movement, control vehicle speeds and warn of potentially hazardous conditions. Traffic control devices notify road users of regulations, provide warnings, and assist motorists with guidance and navigation in order to safely traverse any road open to public traffic.

(a) Important Requirements of Traffic Control Devices

To be effective, traffic control devices must meet the following requirements.

- Fulfil a need;
- Command attention;

- Convey a clear, simple meaning;
- Command respect from road users, and
- Give adequate time for response.

Design, placement, operation, maintenance, and uniformity are aspects that should be carefully considered in order to maximize the ability of a traffic control device to meet the five requirements listed in the previous paragraph. Vehicle speed should be carefully considered as an element that governs the design, operation, placement, and location of various traffic control devices.

(i) *Design:* The combination of physical features such as size, shape, color, composition, lighting or retro reflection, and contrast should be such that as to stand out and attract attention and convey the message clearly.

(ii) *Placement:* The installation of devices should be within the road user's view so that adequate visibility is provided. The location and legibility of the traffic control device should be such that a road user has sufficient time to make the proper response in both day and night conditions.

(iii) *Operation:* As far as possible, the device must be placed and operated in a uniform and consistent manner so that the road-user can adequately respond to it, based on his previous exposure to similar traffic control situations.

(iv) *Maintenance*: A device should be of a high standard and adequately maintained to retain its legibility and visibility. This would command the respect of road-users.

(v) *Uniformity:* All devices must adhere to uniform specifications so that an average road-user can recognize and understand them easily.

(b) Classification

The traffic control devices are classified into the following four main categories:

- Traffic signs
- Road markings
- Traffic signals
- Miscellaneous traffic control devices

5.1 Traffic Signs

Traffic signs are traffic control devices, whether fixed or portable, for conveying warning, information, requirements, restrictions or prohibitions of any description specified by law/ regulation to the traffic on roads. They fall into three broad categories viz. Regulatory signs, Warning signs and Informatory/Guide signs. As far as possible, traffic signs should communicate their message through graphic symbols. The size, color combination and other standards for all road traffic signs have been given in IRC:67 "Code of Practice for Road Signs" and IRC:SP:55 "Guidelines on Traffic Management in Work Zones."

5.2 Road Markings

Road markings are probably the simplest, cheapest and most cost-effective. They can regulate,

warn or guide traffic through lines, symbols or words. They also serve as symbolic barriers for separating the opposing streams of traffic; provide information for turning movements, special zones; and so on. They are very important at intersections to guide pedestrians across the carriageway and thus promote road safety. They not only contribute to road safety but also to the comfort and confidence of the driver.

Road marking must attract immediate attention, have adequate legibility for the approach conditions and convey a precise meaning to provide sufficient time for the driver to respond. Road markings mainly include central line; traffic lanes; pedestrian crossings; stop and give-way lines; no-overtaking zones; carriageway width reduction and transition markings; pavement edge lines: route direction arrows; bus stops; parking space limits; speed limits and speed reductions; cycle track and yellow box to indicate no-stopping area, etc. The Indian Roads Congress has developed uniform standards for road markings and presented in IRC:35 "Code of Practice for Road Markings".

5.3 Traffic Signals

A traffic signal is a traffic control device operated manually, electrically or mechanically by which traffic is alternately directed to stop and proceed. Traffic signals, when properly designed, located and operated, achieve one or more of the following:

(i) Effect orderly traffic movement;

(ii) Provide for the continuous flow of traffic in small platoons, through proper coordination at a definite speed along a particular route;

(iii) Allow other vehicles and pedestrians to cross a heavy traffic stream;

(iv) Reduce the incidence of right-angle and pedestrian accidents;

(v) Signals have standard indications which all drivers can follow easily, and are understood more efficiently and effectively at night or in foggy weather than the hand signals of a policeman;

(vi) Control traffic more economically than by manual methods.

Traffic signals can be operated either in isolation which is more common or as coordinated parts of the linked signal system. It is desirable to link signals on a principal traffic route in order to reduce delay and the number of stops at the signals. This is generally accomplished through a master controller that determines the phasing of signals at each intersection of the system. With microprocessor technology, this system can be so programmed as to provide preferential treatment to the major flow at peak times or optimize the traffic movements in the entire area based on various computer-based optimization models (Area Traffic Control System).

The guidelines for design, installation and other requirements of traffic signals have been stipulated in IRC:93 "Guidelines on Design and Installation of Road Traffic Signals".

5.4 Miscellaneous Traffic Control Devices

The traffic control devices described in para 5.1 to 5.3 are normally supplemented by the following devices for improving traffic flow and enhancing road safety:

- **Channelizing Devices**
  - (i) Barricades
  - (ii) New Jersey Barriers
  - (iii) Traffic Cones
  - (iv) Tubular Markers
  - (v) Drums
  - (vi) Hazard Markers
  - (vii) Direction Indicator Barricades
  - (viii) Delineators
  - (ix) Water Filled Barricades
  - (x) Reflective Devices
    - Road Studs
    - Solar Road Studs
  - (xi) Central Refuges
- **Box Junction**
  - (xii) Traffic Calming Measures
    - Thermoplastic Bar Marking
    - Speed-breakers/Humps
    - Tabletop Crossings
    - Small Turning Radius
    - Carriageway Surface Materials that reduce Speeds such as Cobbled Stone
    - Rumble Strips
      - Lighting Devices at Work Zones
      - Portable Variable Message Signs
      - Lighted Traffic Bollards

5.4.1 *Channelizing Devices*

The function of channelizing devices is to warn and channelize the movement of road users through changed path of movement due to the conditions created by work activities in or near the roadway. The channelizing devices adopted directly from IRC:SP:55 "Guidelines on Traffic Management in Work Zones."

(i) **Barricades:** The barricades are used to warn and alert drivers of hazards created by construction or maintenance activities on or around carriageway/footpath. The following requirements must be borne in mind:

(a) These barricades could be of wood, fiber-glass, P.V.C. or mild steel.

(b) Barricades rails shall be retro reflectorized with yellow or white flexible and reboundable sheets of Type IV grade that meets the required parameter as per ASTM D 4956 Clause S2 with black or red stripes sloping downward at an angle of 45° in the direction along which the traffic is to pass. If the barricades are used for traffic calming in a bi-directional (undivided) carriageway, both the front and backside of the barricade rail should be retroreflectors. Additionally, reflective tapes can also be applied at regular intervals on the frame posts for better conspicuity.

(c) If the lane/road is closed to vehicles, vertical yellow and black (or) vertical red and white stripes are used.

(d) The width of each stripe should not be less than 20 cm.

(e) The barricades should be invariably retro reflectorized and if required, shall be equipped with lighting devices for better night-time visibility.

(f) While red light is used at either end of the protected area (on the barricade across the road); yellow light should be put at regular intervals along the longitudinal barricades to guide the motorists along the diverted path. While red light should be a steady indication, the yellow light should be on flashing mode, preferably with directional arrows. Solar power lighting devices may be used for this purpose as is the practice in other countries.

There are four types of barricades, in which Type I and Type II are portable and Type III and Type IV are permanent. Refer IRC:SP:55 for details, including application areas. Typical barricades with its dimensions are indicated in **Fig. 5.1** and **5.2**

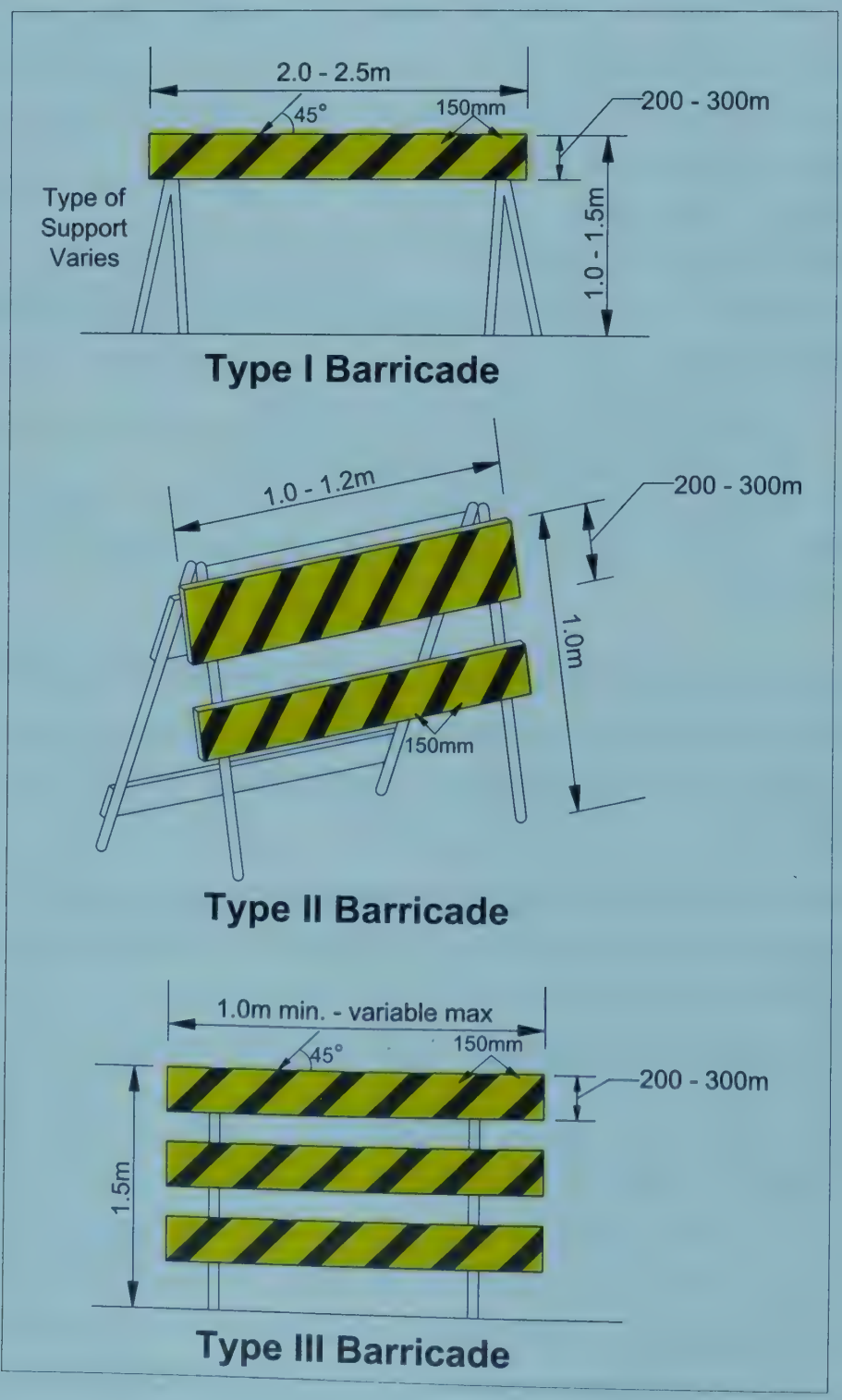


Fig. 5.1 Standard Barricades

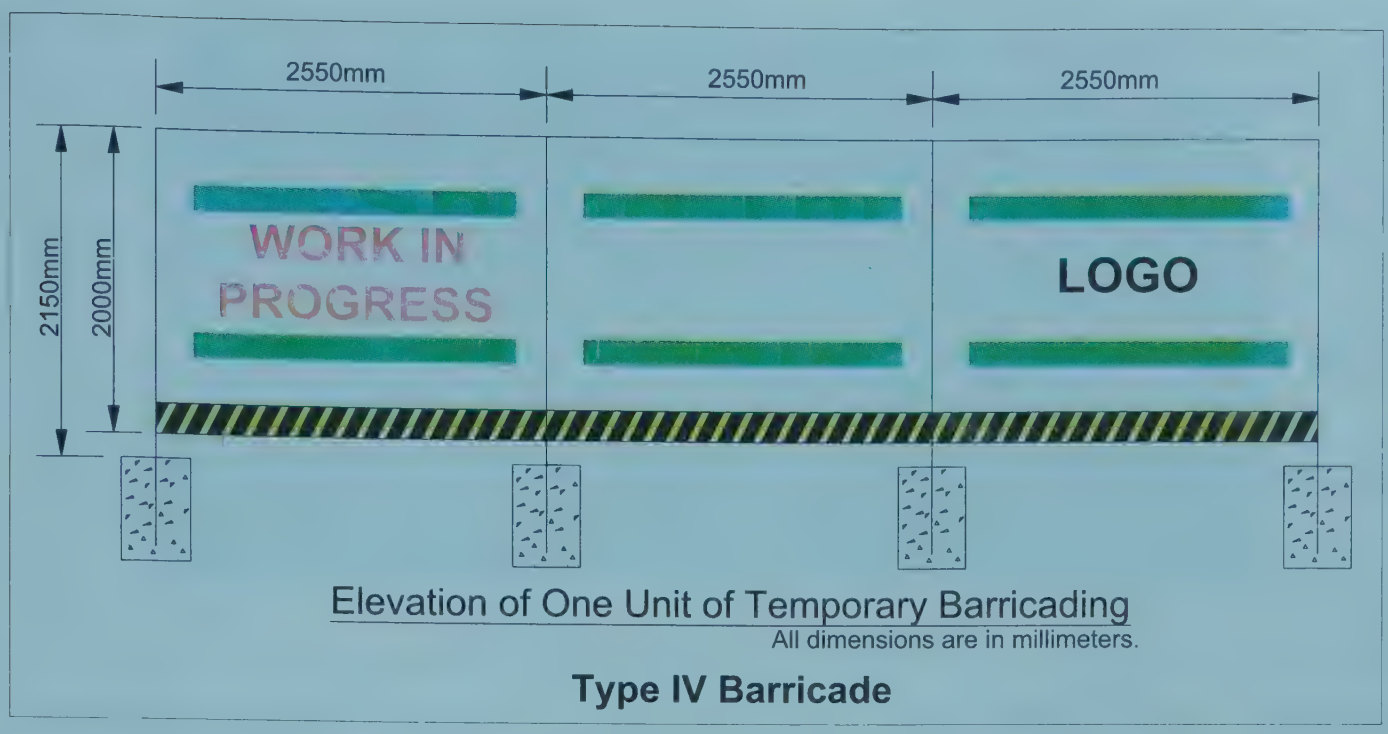


Fig. 5.2 Standard Barricades (Type IV)

(ii) **New Jersey Barriers:** The New Jersey Barriers are 1.5 m to 2.0 m long pre-cast reinforced concrete modular pieces with shaped ends that can be interlocked and connected. Where the road works are to be undertaken, which would continue for some time or where the space is limited, and there is a need for the protection of the work force, particularly where the speed of passing traffic may be high, New Jersey Barrier as shown in **Photo 5.1**. New Jersey barrier is to be used to barricade or segregate work space from traffic, where traffic moves parallel to barricading and it is to be provided at location especially where there is edge drop of more than 300 mm between the carriageway and adjacent strip of land as part of work area. The tapered median (see **Photo 5.2**) allows driver to deceleration for entering into the exclusive or any other storage lane. While installing barricade, the minimum clearance as shown in **Fig. 5.3** shall be kept at all time and refer IRC:SP:55 for details. Barrier shall be retro reflectorized by using Median Markers and Object Markers (see **Photo 5.3**) as per IRC:79.

Photo 5.1 New Jersey Barrier

Photo 5.2 Tapered Median

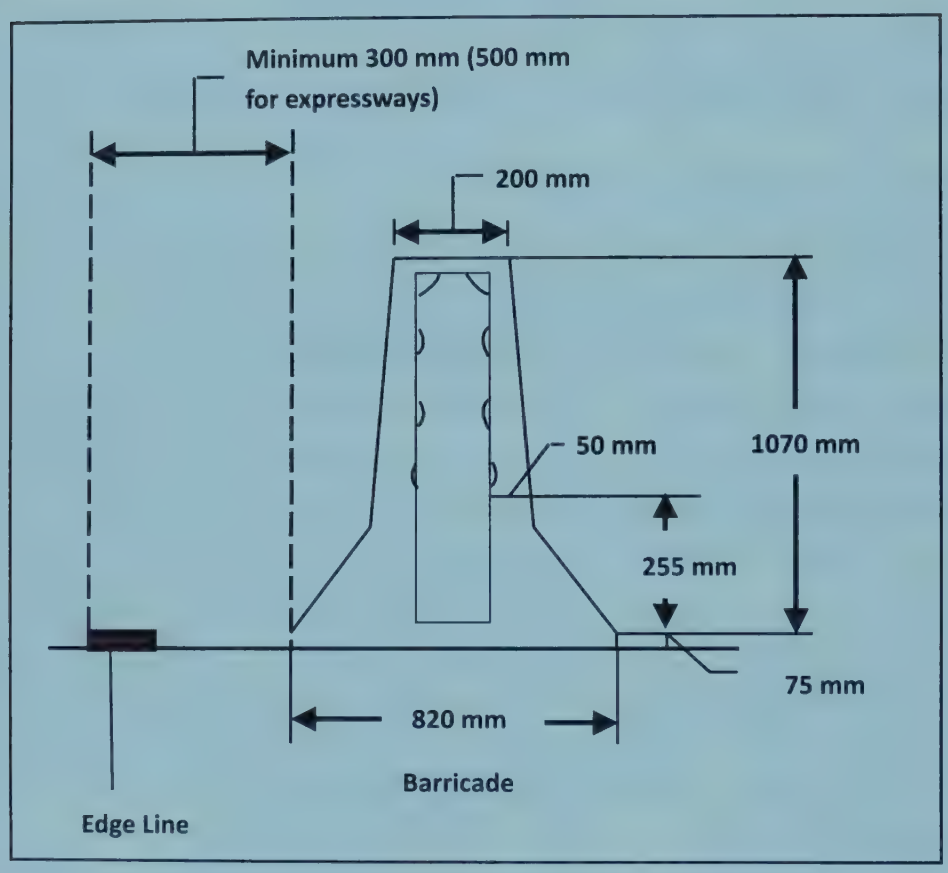


Fig. 5.3 Placement of Barricade along with Object Hazard Marker and Flexible Median Markers

Photo 5.3 Placement of Barricade along with Object Hazard Marker and Flexible Median Markers

(iii) **Traffic Cones:** These are temporary portable devices used to delineate the diverted path either around an obstacle or to create additional space for traffic movement. They should have the following important features:

(a) They are generally conical in shape with a minimum height of 50 cm and maximum of 100 cm.

(b) They should have a broader and heavy base for stability so that they do not fall down easily.

(c) Cones are of brilliant red/orange/yellow color with white bands and the material used must be UV stabilized for better durability.

(d) Though these devices could be of fiberglass, plastic or special rubber, they must be capable of withstanding impact without damage to themselves or to vehicles.

(e) For night use they should be invariably retro reflectorized and if required, it shall be equipped with lighting devices. Cones shall have minimum two retro-reflective white bands of size 150 mm and 100 mm size with flexible reboundable retroreflective sheeting of Class B Type IV grade that meets the required parameter as per ASTM D 4956 Clause S2. The cones shall also have sufficient provisions for the installation of lighting devices on the top and for attaching chain/railings.

(f) Traffic Cones shall be tested for its physical performance such as Stability & Drop Resistance, coefficient of retro reflection of wet retroreflective samples (shall meet Type IV grade values), Adhesion of Retro-reflective Surface as per the European standard EN 13422

The typical traffic cone and their dimensions are indicated in **Fig. 5.4** and refer IRC:SP:55 for details.

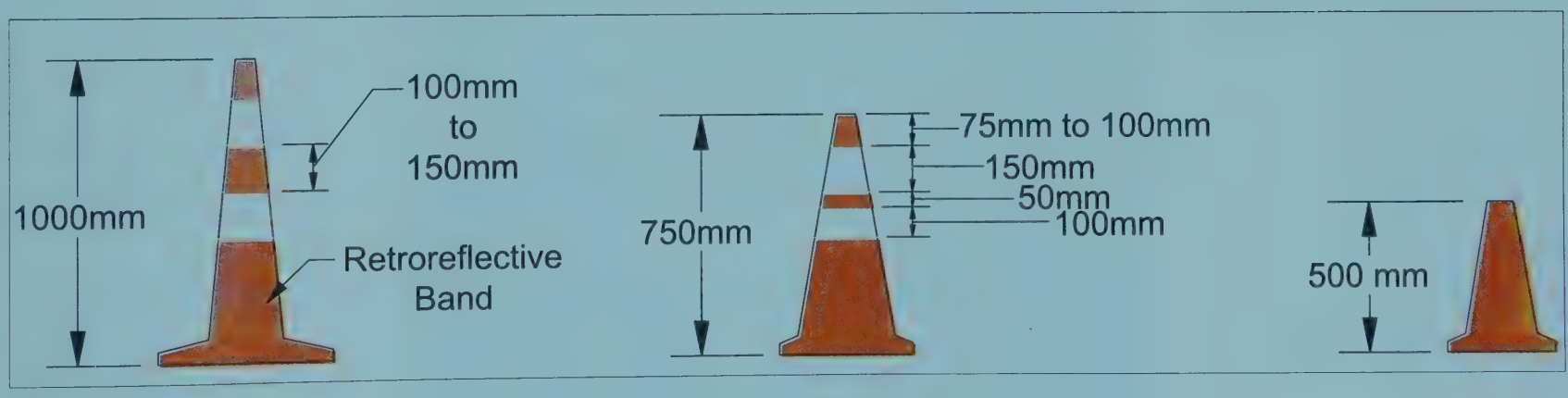


Fig. 5.4 Traffic Cones

(iv) **Tubular Markers:** Tubular markers **(Photo 5.4)** are suitable in urban or in rural sections where pedestrian and cyclist movements are there due to abutting roadside activities. If the traffic approaching in one direction is required to be diverted into two different pathways, it can be used in a longitudinal direction along with traffic lane line marking. It is generally used where traffic moves at relatively slow speed and traffic volume is relatively high. Tubular Markers should be reflectorised for night visibility. Refer IRC:SP:55 for details. Tubular Markers will be used in a situation where there is acute space constraints to install larger devices.

They should have the following important features:

a) A minimum 300 mm clear distance shall be provided from the traffic lane marking to the tubular markers.

b) Tubular Markers shall have minimum two retro reflective white band

c) Tubular Marker shall be tested for its physical performance such as Bending test, Fatigue test, measurement of coefficient of retro reflection of wet retroreflective samples (shall meet Type IV grade values), Adhesion of Retro-reflective Surface as per the European standard EN 13422.

Typical Tubular markers and their dimensions are indicated in **Fig. 5.5**.

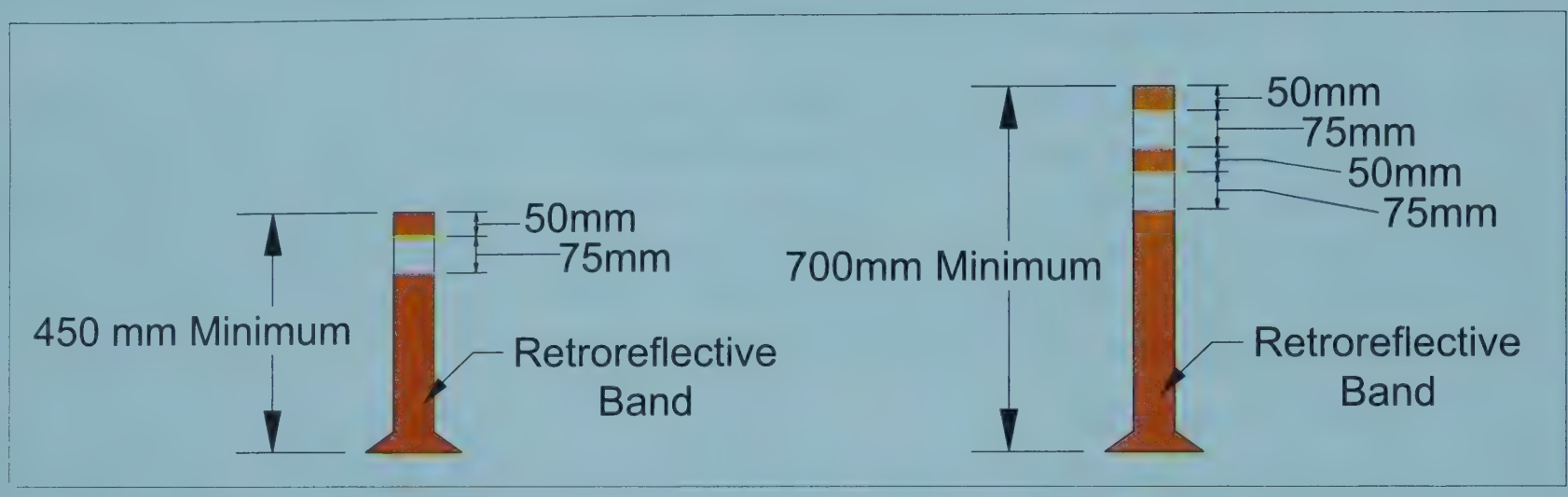
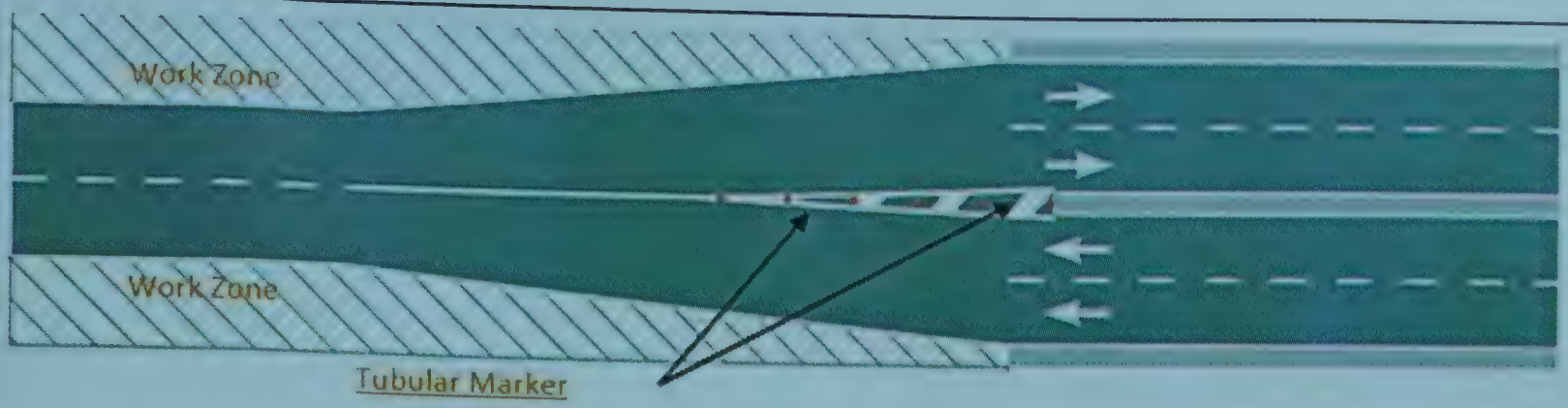


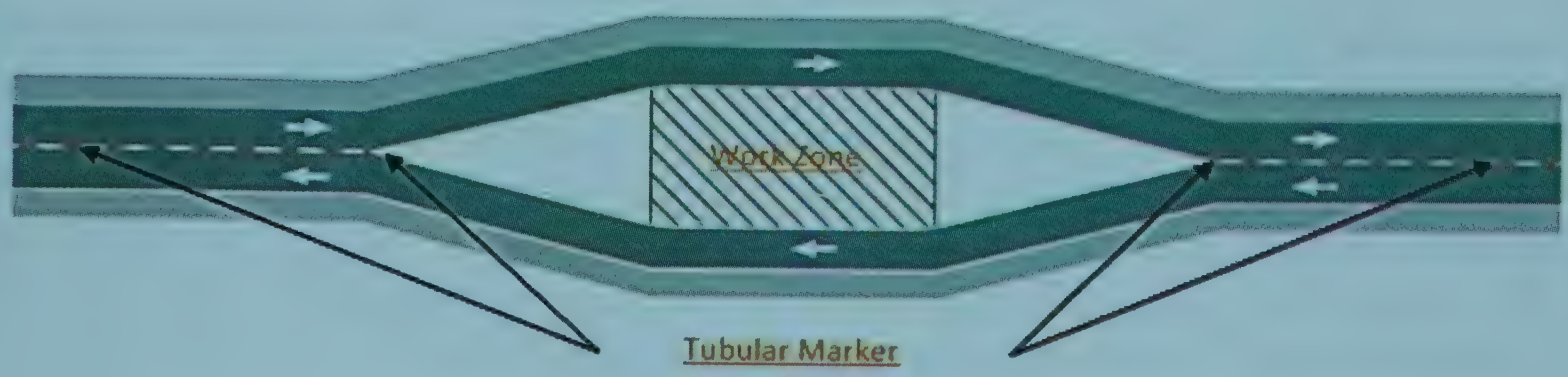
Fig. 5.5 Tubular Marker Dimensions

Photo 5.4 Tubular Markers and their Application

Traffic Cones, tubular markers and drums play a critical role in the traffic management. These devices help in the management of traffic at the locations where temporary traffic control measures are adopted. **Fig. 5.6** presents typical placement of tubular marker/spring post on work zone or traffic diverging/merging sections along with the channelizing devices and traffic signs. Please refer IRC:SP:55 for further details on the placement of traffic cones, drums, barricades and traffic signs barricades and traffic signs.



(a) Tubular markers at the start/ End of the work zones (2 Lane to 4 Lane – Concentric)



(b) Tubular markers at One Direction for major work at the Center of the Road

Fig. 5.6 Tubular Markers at the Work Zone

Locations, where physical segregation of vehicles travelling in opposite direction becomes essential and concrete dividers, cannot be provided due to space constraints, it is advisable to have tubular markers installed on the double center line of the carriageway. **Fig. 5.6** presents an example of an application of tubular posts at work zones

v) **Drums:** Drums used for road user warning or channelization shall be constructed of lightweight, deformable materials. They shall be a minimum of 80 cm in height and have at least a 30 cm minimum width regardless of orientation. The markings on drums shall be horizontal, circumferential, alternating red and white retro-reflective stripes of 100 to 150 mm wide conforming to Type IV Standards (Reboundable flexible reflective sheeting as per ASTM D 4956 Clause S2). Refer IRC:79 and IRC:SP:55 for details.

The following points must be borne in mind while placing drums:

(a) Drums shall have closed tops that will not allow the collection of construction debris or other debris.

(b) Metal drums shall not be used.

(c) Drums should not be weighted with sand, water, or any material to the extent that would make them hazardous to road users or workers when struck.

Typical Drums and their dimensions are indicated in **Fig. 5.7**.

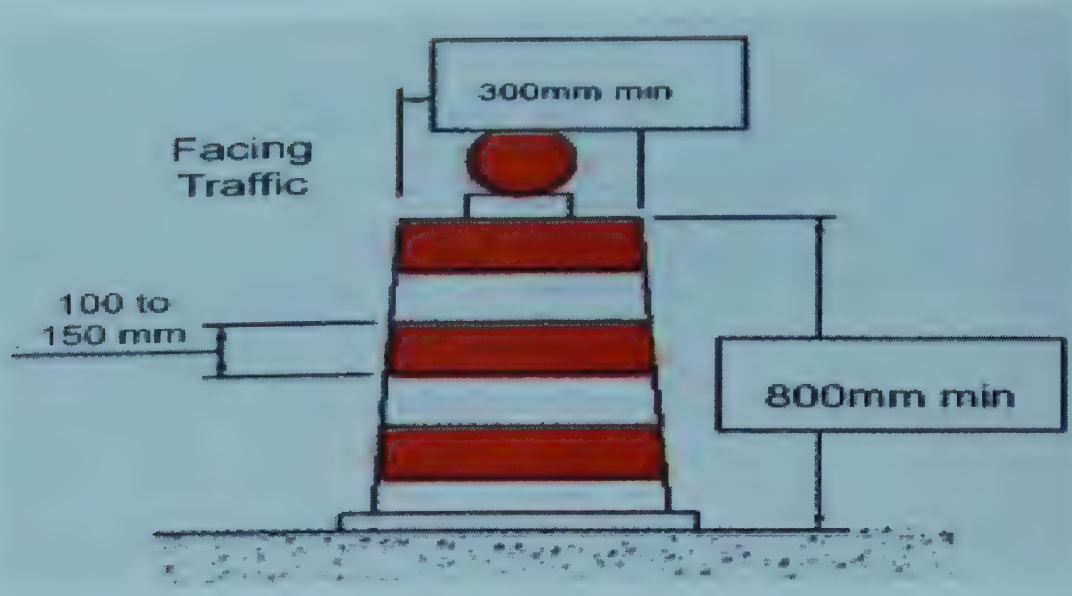


Fig. 5.7 Drum

(vi) **Hazard Markers:** The hazard markers shall be alternating yellow and black retro-reflective stripes of Type XI sheeting conforming to ASTM D 4956, sloping downward at an angle of 45 degrees in the direction of vehicular traffic. With respect to the position of traffic movement and roadside hazard, it can be for either left or right i.e. OHM (Left & Right). If traffic can pass on both sides, it shall be Two Way Hazard Markers (TWHM). The typical alignment of one-way and two-way hazard markers are shown in **Photo 5.5** and dimensions are indicated in **Fig. 5.8**. Refer IRC:67 and IRC:SP:55 for details.

Photo 5.5 Alignment of Hazard Markers

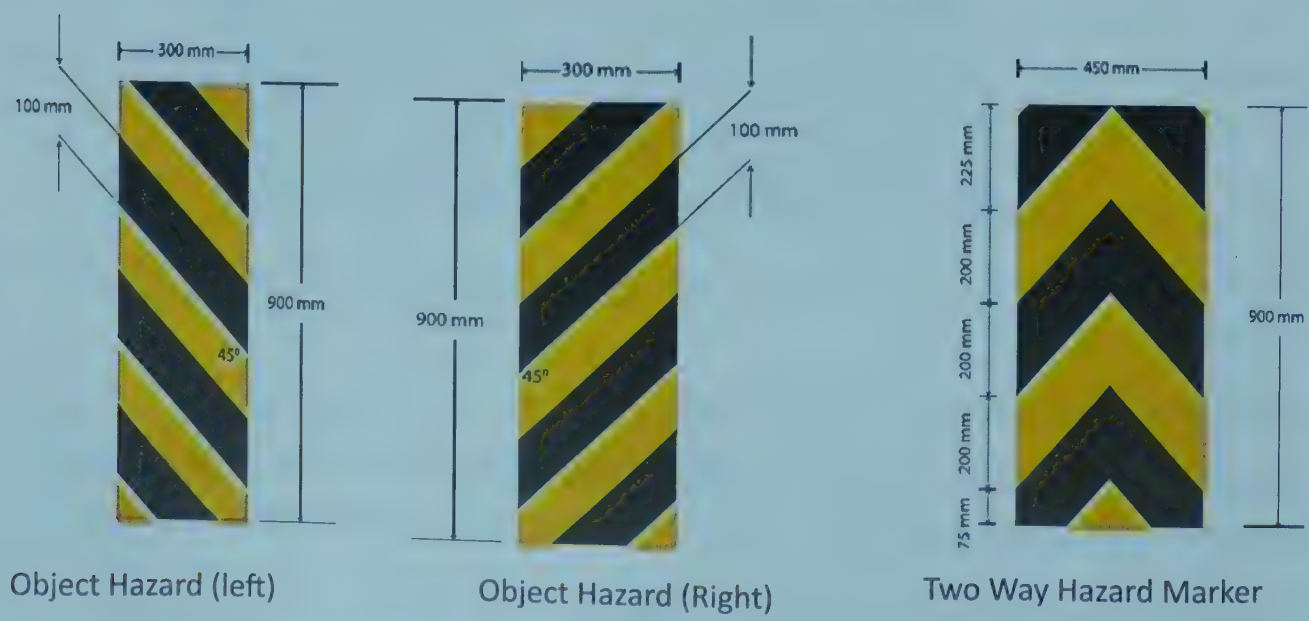


Fig. 5.8 Object Hazard Markers

vii) **Direction Indicator Barricades:** The direction indicator barricade shall consist of a one-direction large arrow sign mounted above a diagonal striped, horizontally aligned, retro-reflective rail. Refer IRC:SP:55 for details. The following points must be borne in mind while placing:

(a) The one-direction large arrow sign shall be white on a red background.

(b) The strips on the bottom rail shall be alternating yellow and black.

(c) The strips shall be 100 mm wide and one direction large arrow sign shall be of size 600x300 mm

(d) The bottom rail shall have a length of 600 mm and height of 200 mm.

(e) The direction indicator barricading, including any associated ballast or lights, should be crash worthy.

ypical Direction Indicator Barricade and their dimensions are indicated in **Fig. 5.9** and **hoto 5.6**.

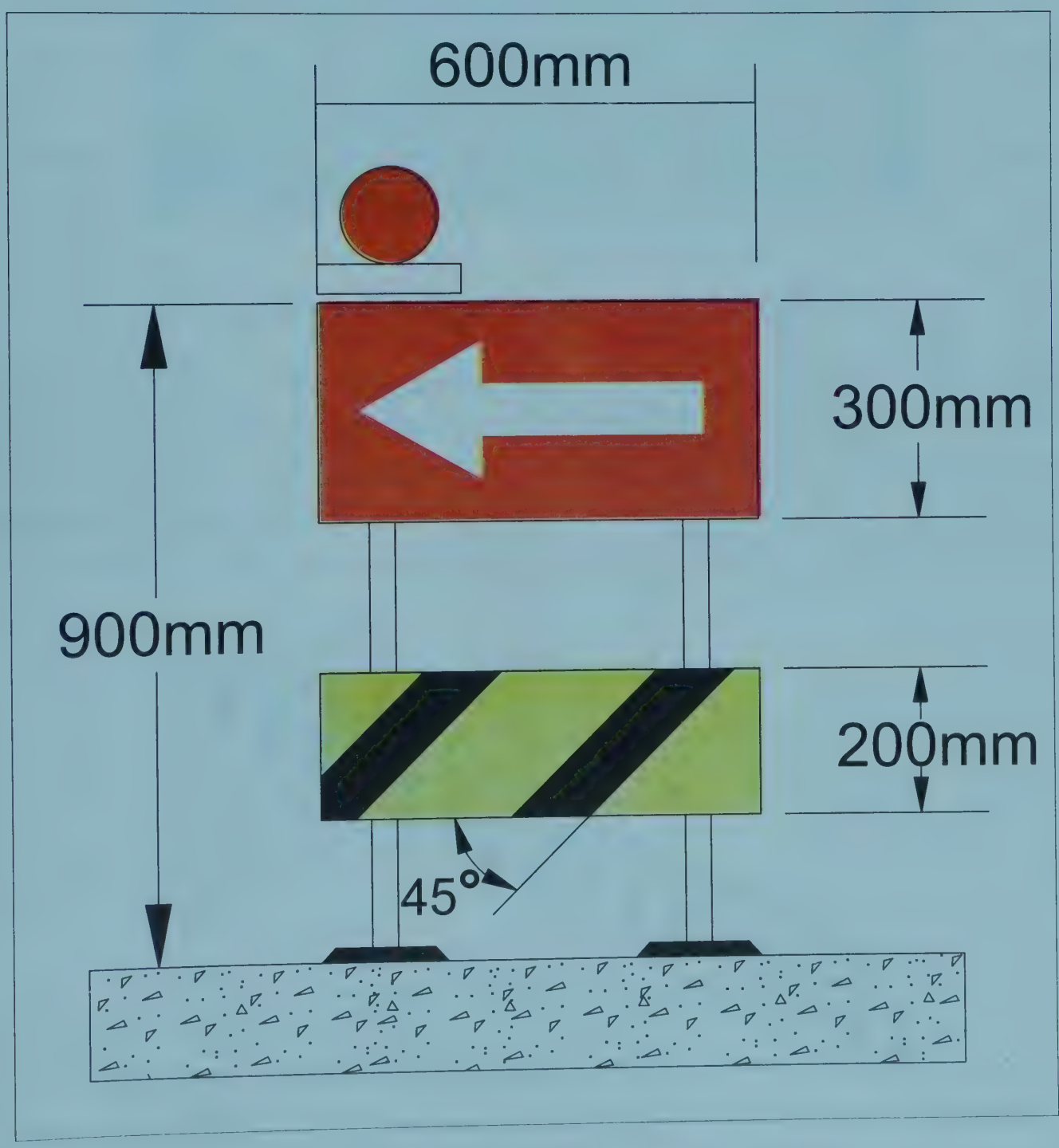


Fig. 5.9 Direction Indicator Barricade

Photo 5.6 Direction Indicator Barricade

(viii) **Delineators:** The delineators are generally combined with or are used to supplement other traffic control devices. They shall be mounted on crashworthy supports so that the reflecting unit is 1.2 m above the nearside carriageway edge. The devices as given in IRC:79, including cones, drums and tubular markers, can be used as delineators. Refer IRC:79 and IRC:SP:55 for details and few delineators are given in **Photo 5.7**

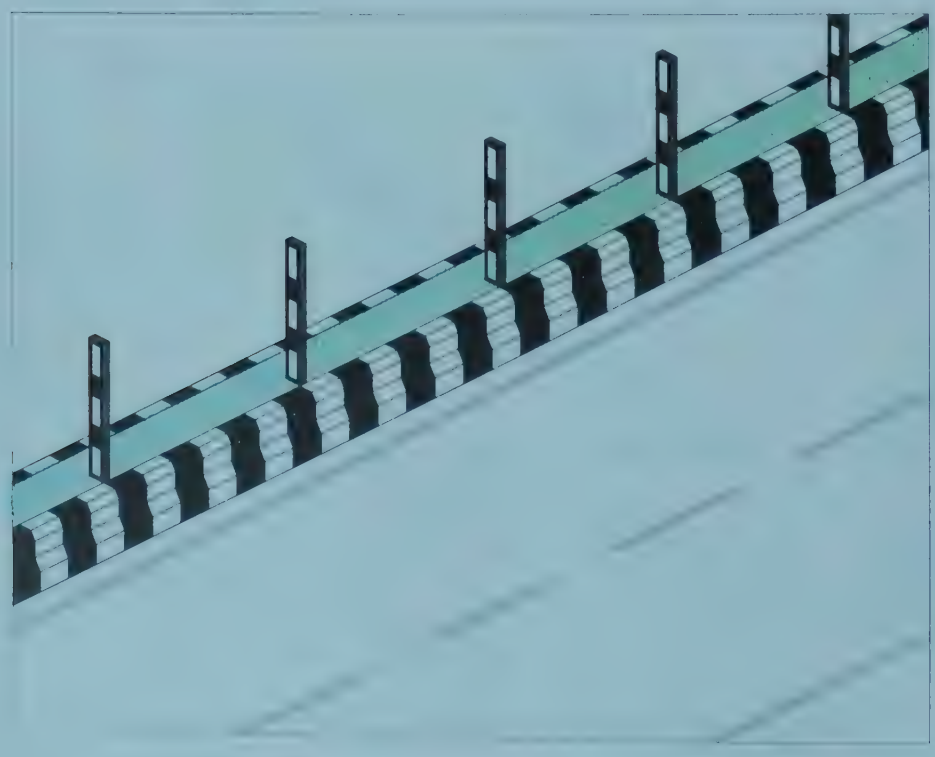


Photo 5.7 Delineators

(ix) **Water Filled Barricades:** The water-filled barricades are modular water-filled plastic containers of various sizes and shapes. Hollow polyethylene barriers in trapezoidal shape of about 80 cm to 100 cm length have been developed for short term applications where portability is important. Refer IRC:SP:55 for details and typical alignment of Water-Filled Barricade given in **Photo 5.8**

The following points must be borne in mind while placing:

a) They shall be minimum 0.7 m tall for major roads and expressway, and 0.5 m tall for other roads.

b) Each unit shall come with interlocking devices for use on tangent/ straight and horizontal curves with a mounting arrangement to fix devices for lighting.

c) It is very stable and offers better resistance to vehicle impact as compared to traffic cones and barricades.

d) It shall be used as a traffic delineator for long term works to separate traffic from pedestrians when the footpath is temporarily diverted next to a carriageway.

e) It shall be placed at least 0.5 m from the edge of the carriageway for expressway and 0.3 m for other roads.

f) Reflective sheeting to be placed on these plastic barricades shall conform to class B Type IV flexible and reboundable sheet as per IRC:67.

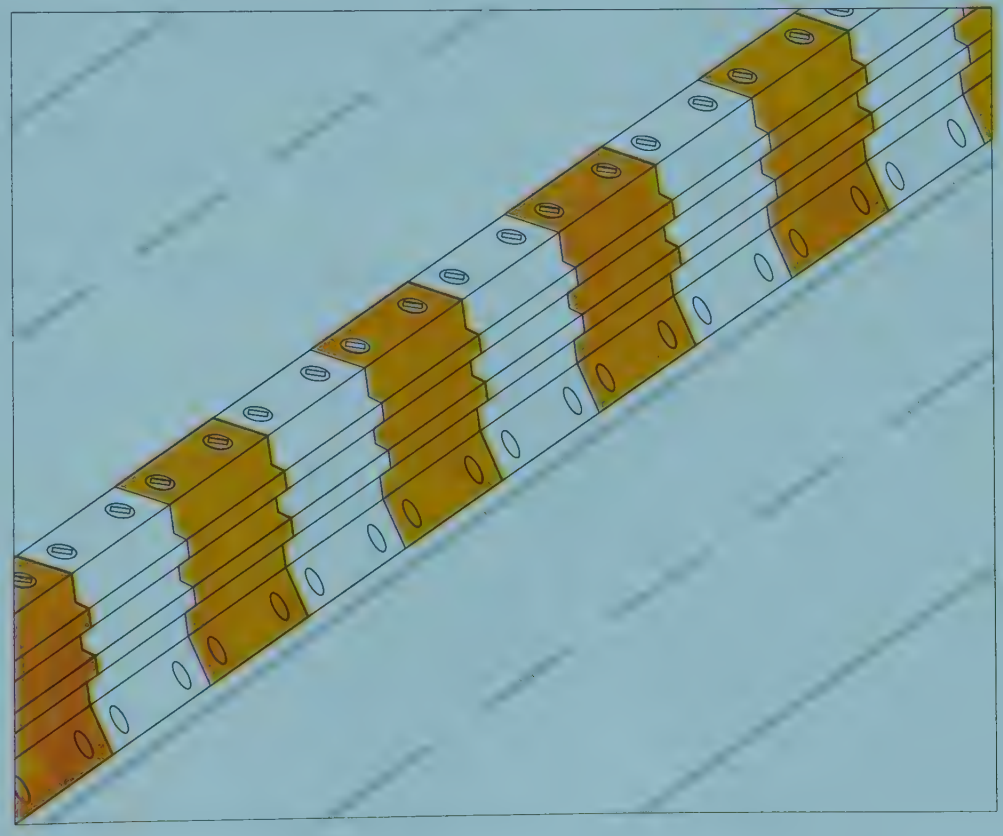


Photo 5.8 Water Filled Barriers

(x) **Reflective Devices:** Reflective devices such as cat's eye/road studs and solar studs, flexible median marker, delineators, tubular markers and object marker shall be placed on the pavement along with the markings, kerb and dividers median, the crash barrier or any hazardous structure to warn and guide motorists during night time.

The following points must be borne in mind while placing:

a) The underlying principle is that when head-light falls on such devices, they reflect light and become self-illuminating and visible.

b) These are recommended for bridges, toll plazas, sharp curves, pedestrian crossings, lane transitions, speed humps, junctions, construction sites, railroad crossings, median openings, accident-prone locations, median, any concrete structure, crash barriers and lane changing locations.

The typical arrangement of road studs is indicated in **Photo 5.9**.

a) **Road Studs:** Road studs shall be used at acute temporary diversions to reinforce the temporary continuous marking and also where the contra flow situation is required to be adopted as part of work zone traffic management plan. Refer IRC:SP:55 for details.

b) **Solar Road Studs:** Solar powered road markers are more active, which can immediately draw the attention of drivers where the performance of normal road studs are not that effective due to street lightings and other roadside activities.

- The solar road studs function automatically and obviously do not rely on vehicle headlight.
- The intense brightness of the Light Emitting Diode (LEDs) makes them visible at distances of more than 800 m under favourable conditions. Its LED shall have the capability to give a 360-degree visibility
- The solar studs are also more distinctly visible during rainy and foggy conditions where the road markings could be ineffective.
- The Solar studs shall have the proper Ingress protection preferably IP 68 to withstand in rainy condition
- It shall be made with Polycarbonate body with load-bearing capacity of 13.65 tonnes are per IRC:35

Photo 5.9 Road Studs

(xi) **Median Markers:** Flexible Median Marker (FMM) should be used for illumination of median as well as parapet wall structures etc. Use of Median Marker provides safety against collision happening with medians/parapets during the night time or severe weather. Recommended minimum application distance is 2 m in the case of urban areas, 5 m for interurban highways and expressways or as suggested by Engineer in-charge. Please refer to IRC: 79 for details on Median Marker. **Photo 5.10** shows median marker.

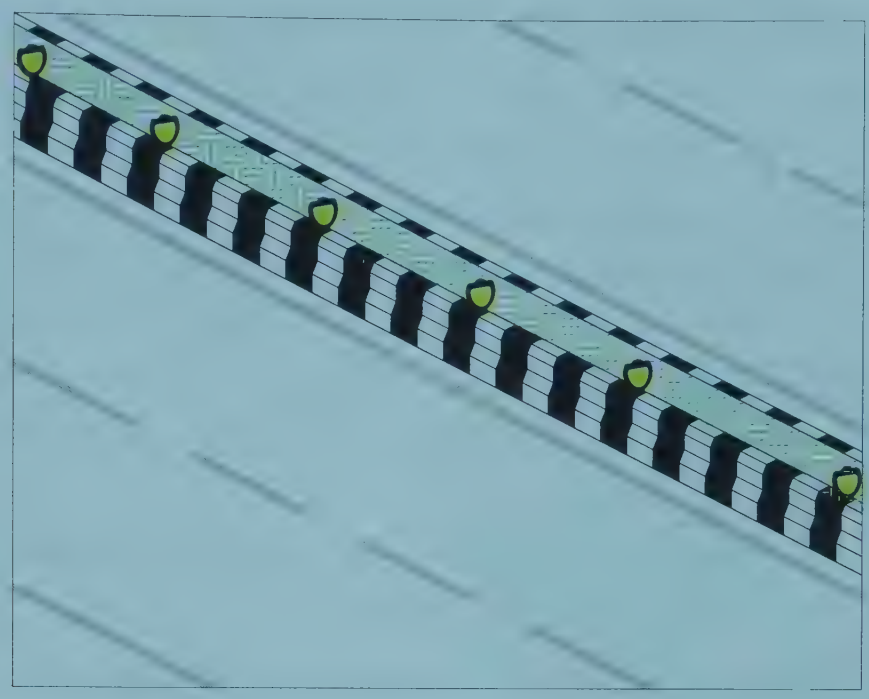


Photo 5.10 Median Markers

(xii) **Object Markers:** Aluminum-backed flexible prismatic sheeting shall be used for application on the beam and post of the metal crash barrier or porous concrete structure like roundabout, at bull noses, Traffic Police/Toll Booth Structures, as well as at entry/exit points of the Tunnel structures aimed at enhancing night time visibility. Refer IRC:79 for details on Object Marker **(Photo 5.11)**

Photo 5.11 Object Markers

(xiii) **Central Refuges:** The refuge island **(Fig. 5.10)** (IRC:103) provides a place of safety for pedestrians to enable them to cross wide roads which, ordinarily, they could not have crossed at one time because of changing traffic signals or continuous stream of oncoming traffic from the opposite direction. A typical use of the refuge is on roads where small number of people habitually crosses at different points for one reason or the other. The important requirements are listed below:

(a) A central pedestrian refuge should have raised curb and should not be less than 1.2 meters in width and 3.6 meters in length. Openings or dropped curbs should be provided in the centre island to assist pedestrians.

(b) Pedestrian central refuge should be properly highlighted with the help of road markings and road furniture like delineators, median markers or solar studs based on the site requirement. This will help to warn the motorised vehicle users about the possible presence of pedestrians on the road ahead.

(c) A refuge island should not be provided on a road which has width of less than 12 meters roadway width.

(d) As far as possible, Refuge Island should not be installed in isolation; otherwise, it would be vulnerable to collision by vehicles.

(e) Parking and loading/unloading restrictions should be ordinarily considered on either side of the refuge island up to a distance of 50 meters on each side.

(f) Lighted traffic bollards must be fixed at each end of the refuge island so that vehicles are forewarned of the impending obstruction on the road during night time.

(g) The lighted traffic bollard should be sufficiently high and wide to be conspicuous; the ideal height is 1.2 meters.

(h) Zebra crossing may be considered at such refuge islands across the road.

(i) The refuge island should be invariably painted with black and white stripes so as to be conspicuous from a distance.

(j) Where the pedestrian traffic is very heavy, overhead halogen lights are also recommended so as to make the pedestrian crossings not only conspicuous but also to have a psychological effect on motorists about something important. It automatically commands respect from motorists because pedestrians are visible even from a reasonable distance.

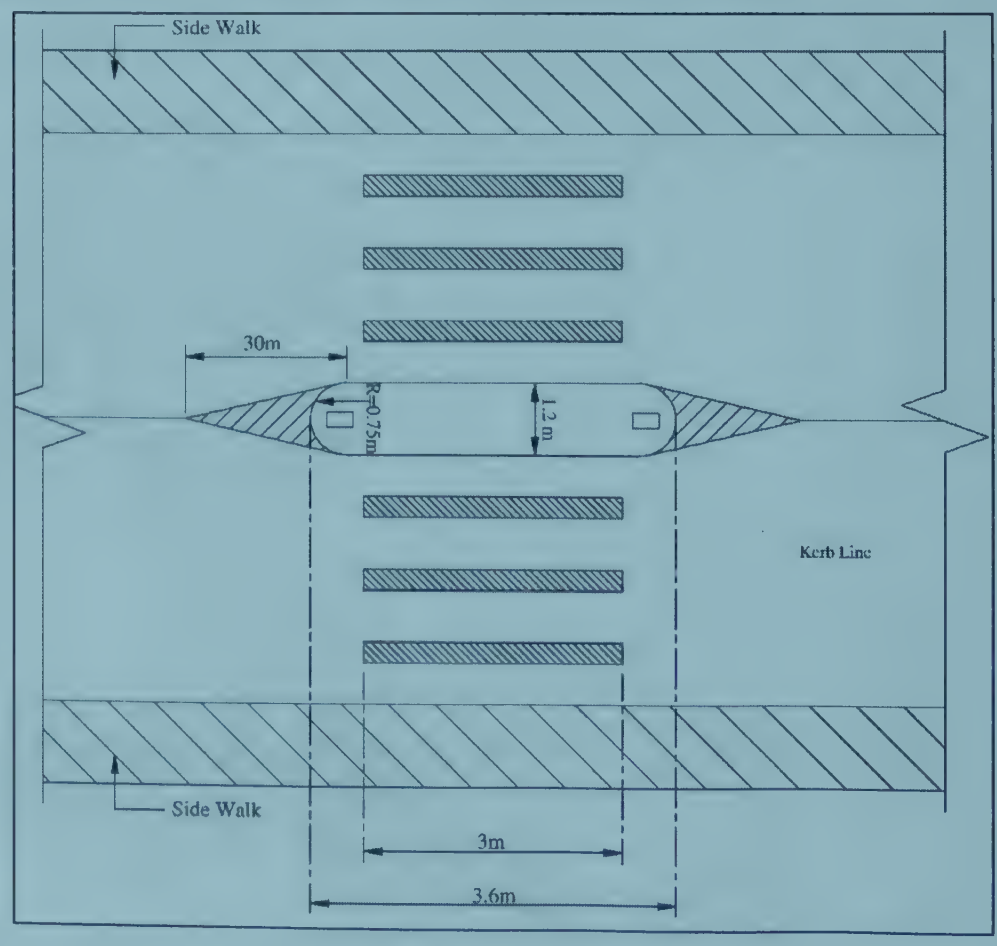
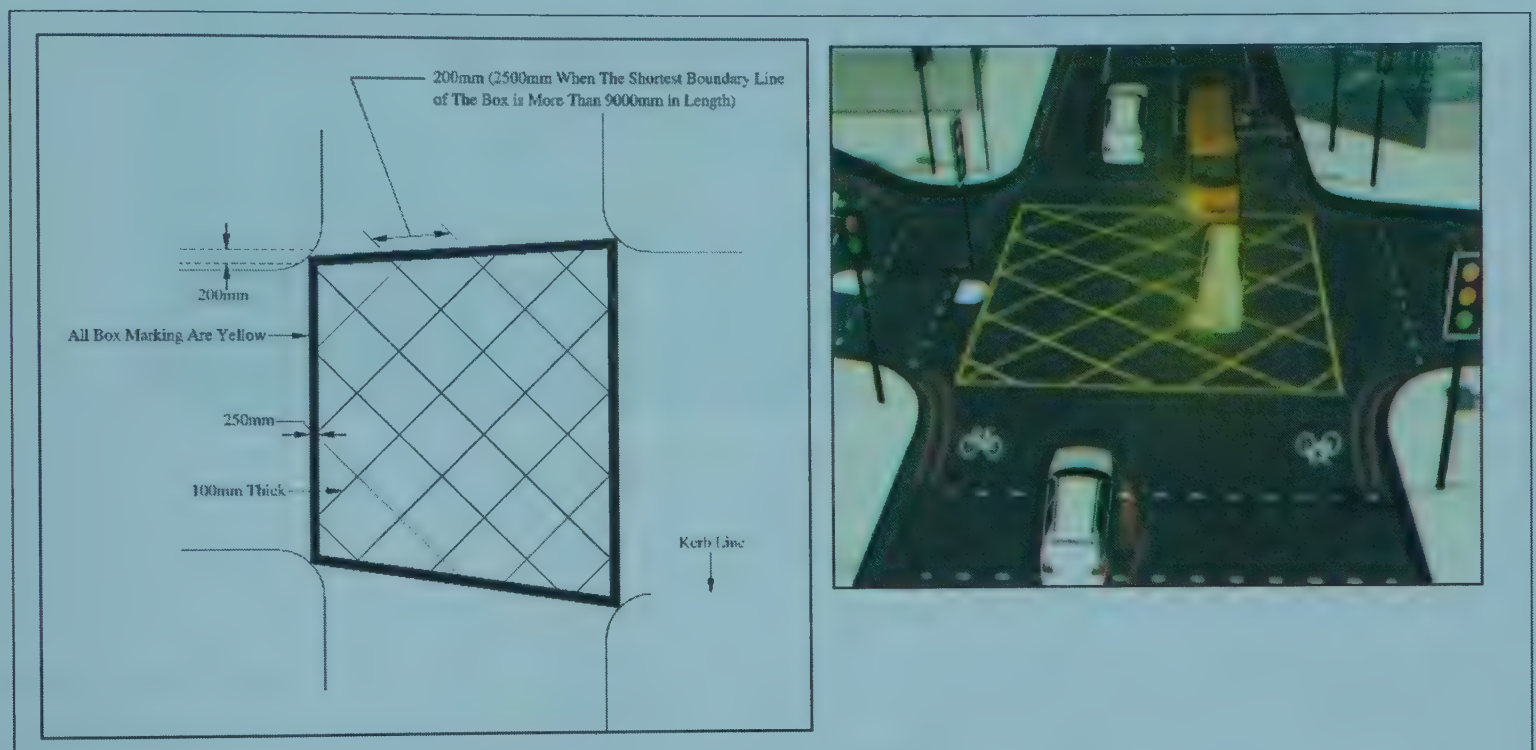


Fig. 5.10 Refuge Island

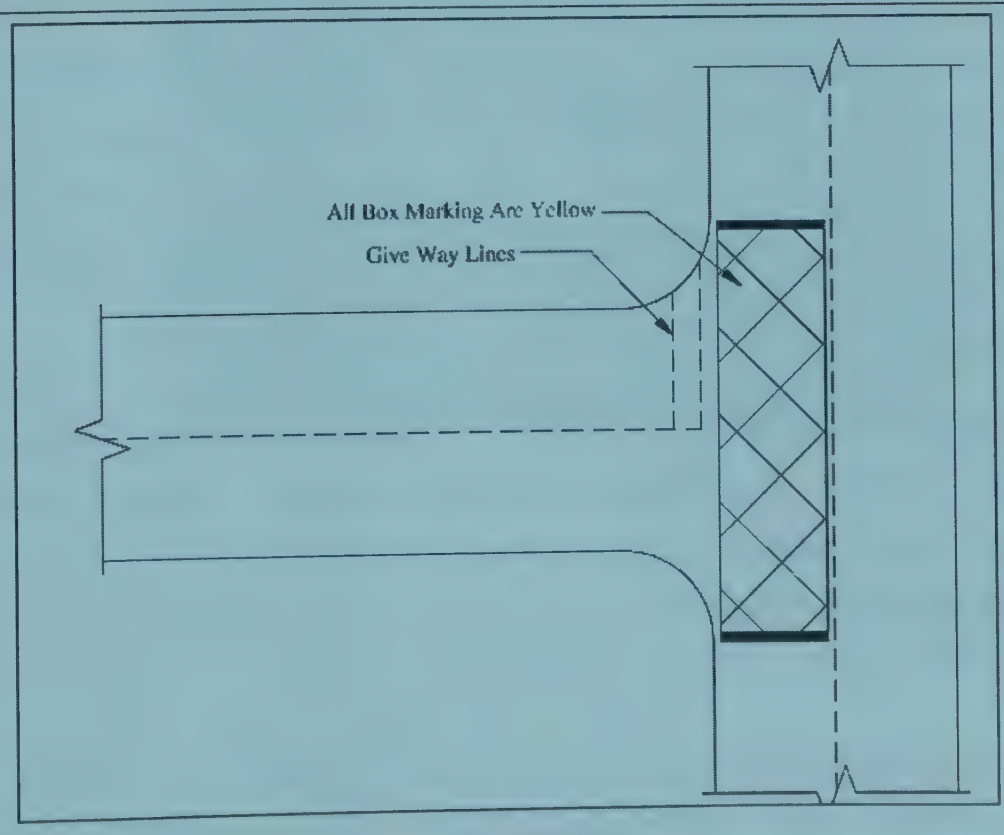
.4.2 *Box Junction*

he critical junctions/areas are marked with yellow crossed diagonal lines in the form of a box to ndicate the area where vehicles must not become stationary even for a short while. Regulations re introduced by legal notifications to prohibit drivers from entering such area even if the signal ght is green unless they are sure they will be able to clear the area immediately. This ensures nat in event of heavy traffic ahead, neither the junction is choked nor the cross-traffic and edestrian movement across the road is adversely affected.

is absolutely imperative to display sign-boards adequately and conspicuously to forewarn notorists about the box junction **(Fig. 5.11)**. The width of crossed-diagonal lines should be 10 m; these lines must necessarily be yellow alone. Refer IRC:35 for details.


200mm (2500mm When The Shortest Boundary Line of The Box is More Than 9000mm in Length)
200mm
All Box Marking Are Yellow
250mm
100mm Thick
Kerb Line

a) Four Arm Junction



b) T-Junction

Fig. 5.11 Box Junction

5.4.3 *Advanced Stop Lines*

An advanced stop line is a second stop line located several meters after the main vehicle stop line on a signalised intersection approach. The vehicle stop line and advanced stop line create a "box" that can be used by exclusive non- motorized vehicles or motorized two-wheelers depends on the priority of vehicles. **Photo 5.12** presents advanced stop lines at Box Junction

Photo 5.12 Advanced Stop Lines at Box Junction

5.4.4 *Traffic Calming Measures*

The central theme of traffic calming is to reduce the adverse impact of motor vehicles on built-up areas. The techniques usually involve reducing vehicle speeds, providing more space for pedestrians and cyclists, and improving local environment. The basic principle of traffic calming remains universal, which is to lower the vehicle speeds in order to reduce accidents, pollution and enhance the livability of surrounding areas. It is essential to adhere to the specifications "Guidelines for Traffic Calming Measures in Urban and Rural Areas (IRC:99)". The main classification of traffic techniques are Active (Design enforced) and Passive (Law enforced).

Active or Design Enforced

(i) **Speed-breakers/Humps:** Speed-breakers are traffic control devices which alert the driver of a change in conditions and break speed of vehicles. Speed breaker/ humps may be several varieties; the rounded (circular) and flat topped (trapezoidal) being the most common for details refer "Guidelines for Traffic Calming Measures in Urban and Rural Areas (IRC:99)".

Speed breakers can be provided across feeder roads (minor/sub-arterial) and not on arterial roads. Across arterial roads, High raised pedestrian crossings can be provided **(Photo 5.13)**. These were provided way back in 2005-06 in Bengaluru. These can be provided near Schools, Hospitals, Religious places and cross roads.

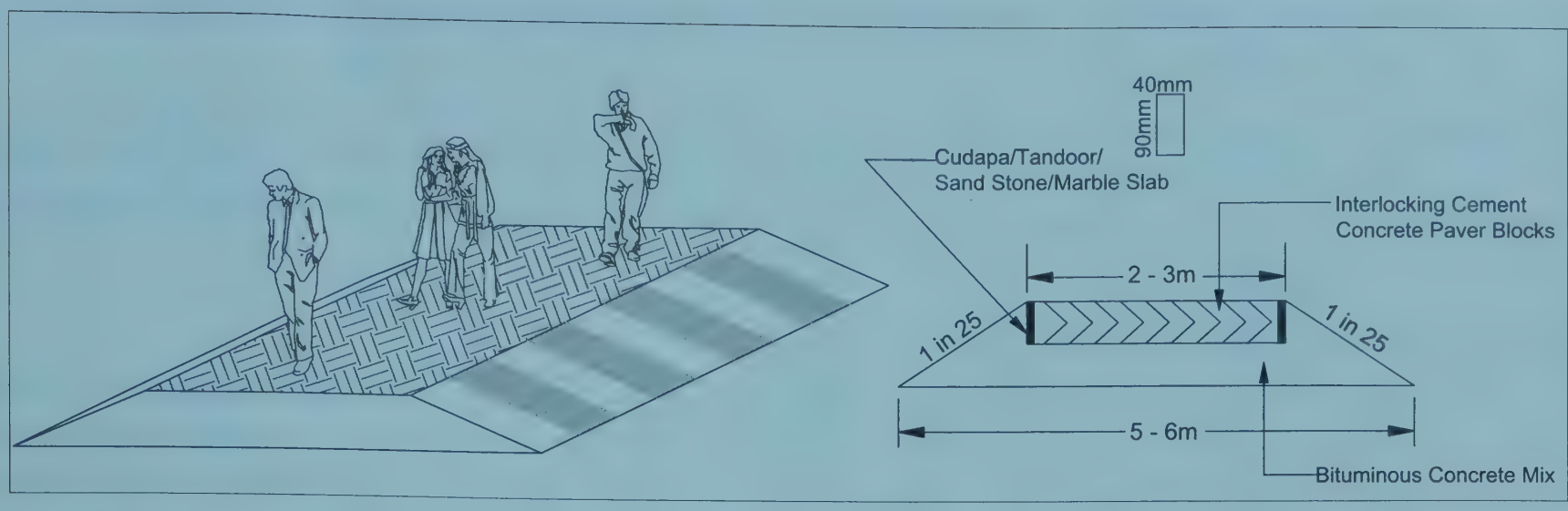


Photo 5.13 Raised Pedestrian Crossing

(ii) **Rumble Strips:** Rumble strips can consist of small asphalt stripes placed on the pavement (called rumble strips) or be uniformly but gradually raised surface with horizontal top. It is provided at places where speed control is unavoidable in arterial roads. Refer IRC:99 "Guidelines for Traffic Calming Measures in Urban and Rural Areas" for details.

Transverse Bar Marking (TBM): Transverse Bar Marking made up of Thermoplastic bar marking is a softer treatment to reduce the speed. One set of bar marking comprises of 6 bars, 200 to 300 mm wide, 600 mm apart of 5 mm high. Each strip of thermoplastic strip shall be of 5 mm high and 300 mm wide 1000 mm apart of 15 mm high. The number of set of bar marking shall be based on approach speed for details refer IRC:35 and IRC:99. 3D virtual Road markings **(Photo 5.14)** which will give the optical illusion of the zebra crossing (white rectangular prisms) floating above the road. These measures influence driver behavior to slow down vehicle speed at pedestrian crossings. The speed reduction is relatively high in heavy vehicles (Buses, trucks and Heavy Commercial vehicles) due to high vantage view point of drivers than small cars and big cars.

Photo 5.14 3D Marking

Passive or Law Enforced

- *Visual Warning:* applied to ensure drivers become aware of the subsequent speed reducers or changing road speed classification.
- *Road Signs*: Refer IRC:67 for "Code of Practice for Road Signs"
- *Feedback Signs:* Real-time speed of the vehicles on an LED Display
- *Markings*: see IRC:35 "Code of Practice for Road Markings"

- *3-Dimensional Markings on Roads:* Gives an impression to approaching driver which in turn has on effect on speed.

(iii) **Speed Arresters:** Speed arresters shall be placed using the road studs not less than ten rows with the raised markings. These speed arresters are effective in reducing the speeds of vehicles up to the posted speed limit. The placement of speed arresters further guided by the signboards.

The following features must be borne in mind:

(i) Speed-breakers should not be ordinarily installed on major roads where traffic volume is heavy. They are mainly provided on streets with a dead end, crowded residential areas with local traffic, or on sharp curves where there is risk of frequent accidents taking place and on minor roads connecting with major roads (at intersections/ junctions).

(ii) On approaches to railway crossings or weak/narrow bridges, rumble strips should be provided (instead of speed breakers). These should be marked with thermoplastic paint and supplemented by warning/speed limit signs on approaches.

(iii) If the size and shape of speed breakers do not conform to the specifications contained in IRC:99, they may be hazardous to traffic.

(iv) The speed-breakers must be invariably painted with black and white bands, as per IRC:99.

(v) Warning sign-boards indicating the presence of speed-breaker must be conspicuously displayed, at least 40 meters ahead on either side of the device.

(vi) The rumble strips can be cast in-situ with cement concrete or premix bituminous materials.

(vii) Rumple strips provided across the entire width of the carriageway and paved shoulders (if any).

5.4.5 *Traffic Management Measures at Work Zones*

Work Zone is defined in IRC:SP:55, is the stretch/area of a road with construction, maintenance or utility work activities. Signs, channelizing devices, barriers, pavement markings, and/or work vehicles typically mark a work zone. A work zone extends from the first warning sign or flashing lights on a vehicle to the end of road work sign or the last traffic control device. The main points to be considered in Work Zone Traffic Management Plans (WTMP) in urban areas are discussed below:

(i) WTMP in Urban Areas

In urban situations, where road works are to be carried out, more attention should be given to the problems of pedestrians and non-motorized vehicles in places where heavy traffic volumes are involved. The following features must be born in mind:

- Road users should be channelized and routed through and around the area under repair with minimum of delays.
- As pedestrians are likely to be present at urban construction sites, there must always be safety or buffer zone between the outer pedestrian barrier and the traffic.

- Availability of proper sight distance for the movement of vehicles at the recommended speed for the stretch in the work zone should always be kept in mind.

The traffic management measures at Intersections and Flyovers during construction are presented in **Fig. 5.12** and **Fig. 5.13**, respectively.

Fig. 5.12 Traffic Management Measures during Road Work at the Center of the Junction

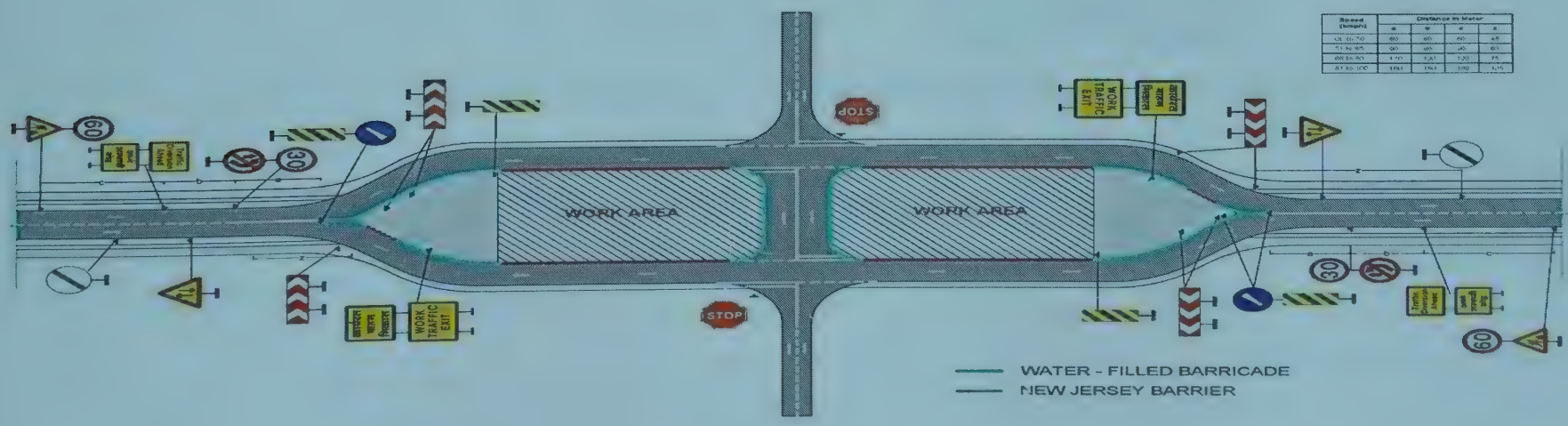


Fig. 5.13 Traffic Management Measures during Construction of Flyover/Underpass

(ii) Work Zone Traffic Management at Major Road or Metro Construction

Traffic diversion plans are required in order to look for options and remedial measures so as to mitigate any traffic congestion situations arising out due to the acquisition of road space

during Metro construction. These measures can be road widening exercises, traffic segregation, one-way movements, traffic diversions on influence area roads, acquisition of service lanes, etc. Various construction technologies are in place to ensure that traffic impedance is at the minimum. They are:

- In 'Cut-and-Cover' method, the stretch between two points will have to be blocked during construction. However, temporary decking may be provided by blocking the road carriageway partially to permit traffic movement along the same stretch if possible.
- Wherever the stations are isolated, areas available around it should be utilized for road diversion purposes such as lay-byes and service roads

(iii) Lighting Devices

Lighting devices should be provided in work zones based on engineering judgment. When used to supplement channelization, the maximum spacing for warning lights should be identical to the channelizing device spacing requirements.

Four types of lighting devices are commonly used in work zones. They are floodlights, flashing warning beacons, warning lights, and steady-burn electric lamps.

Lighting devices may be used to supplement retro-reflectors signs, barriers, and channelizing devices. During day-time/night-time maintenance and operations, the functions of flashing warning beacons may be provided by high-intensity rotating, flashing, oscillating, or strobe lights on a maintenance and operations vehicles as well zones. Some illustrations are given in **Photo 5.15** and refer IRC:SP:55 for details.

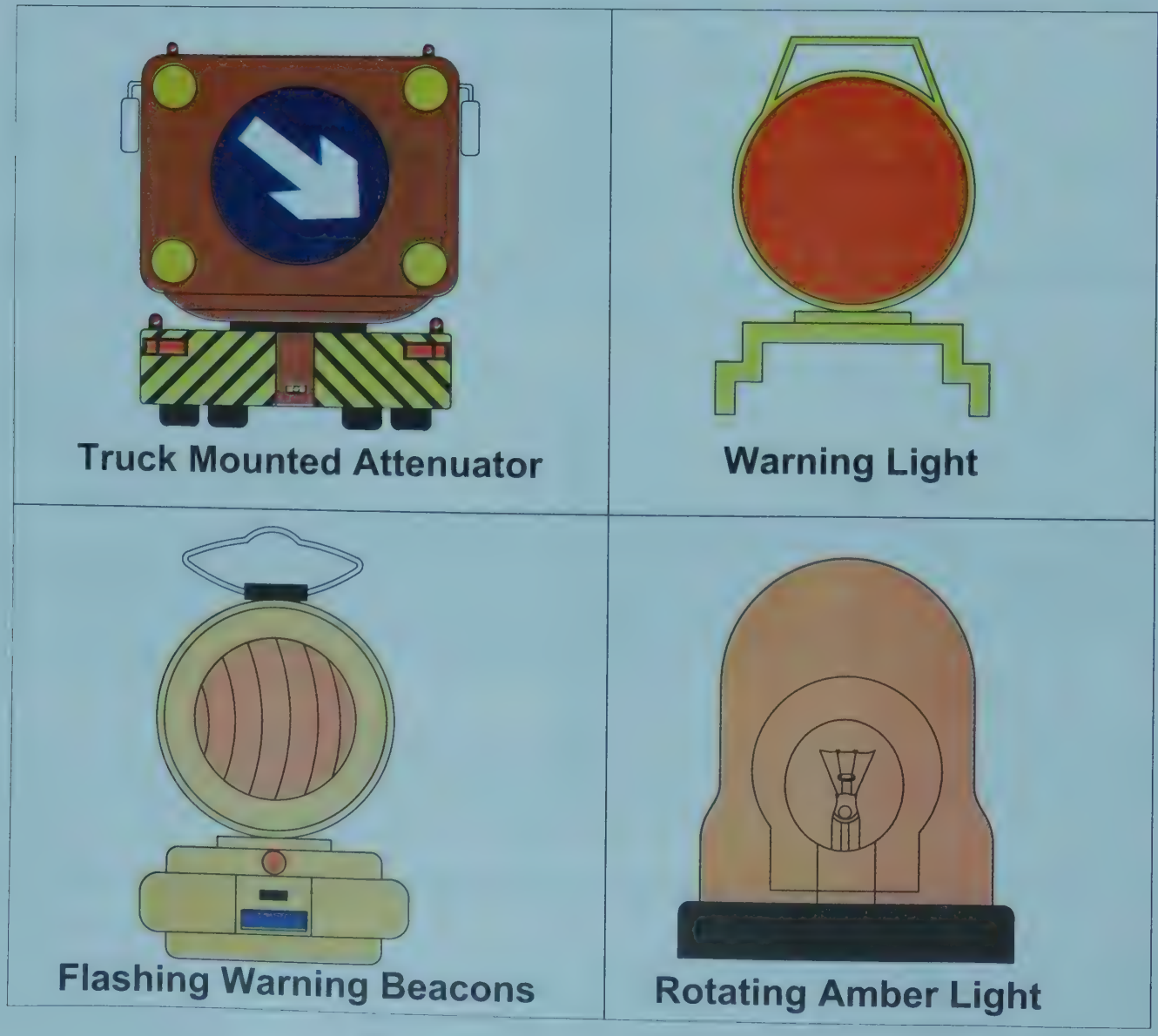


Photo 5.15 Lighting Devices at Work Zones

5.4.6 *Portable Variable Message Signs*

Portable message signs shall be the devices with the flexibility to display a variety of messages. Each message shall consist of either one or two phrases. A phrase shall consist of up to three words of eight characters per name. The message to be conveyed should not exceed three phrases displayed in three lines. In recent years, some newer LED variable message signs have the ability to show colored text and graphics. Portable changeable message signs have a wide variety of applications in work zones including: roadway, lane, or ramp closures, crash or emergency incident management, width restriction information, speed control or reductions, advisories on work schedules, road user management and diversion, warning of adverse conditions, and other operational control.

The components of a portable variable message sign should include a message sign panel, control systems, a power source, and mounting and transporting equipment. It shall also provide an Android based application for Disaster Management and Emergency Messages.

The front face of the sign should be covered with protective material. The color of the elements should be yellow on a black background. Portable variable message signs should be visible from 800 m under both day and night conditions. For a trailer or large truck-mounted sign, the letter height should be a minimum of 450 mm. For variable message signs mounted on service patrol trucks, the letter height should be a minimum of 250 mm.

The message panel should have adjustable display rates (minimum of 3 seconds per phrase), so that the entire message can be read at least twice at the posted speed, the off-peak 85th-percentile speed prior to work starting, or the anticipated operating speed.

Messages should be designed, taking into account the following factors:

a) Each phrase should convey a single thought.

b) If the message can be displayed in one phrase, the top line should present the problem, the centre line should present the location or distance ahead, and the bottom line should present the recommended driver action.

c) The message should be as brief as possible.

d) When a message is longer than two phrases, additional Portable Variable Message signs should be used.

e) When abbreviations are used, they should be very convenient and easily understood.

5.4.7 *Lighted Traffic Bollards*

A lighted traffic bollard is a bright device installed on a channelizers/ islands to forewarn motorists of the impending obstruction threat. It also indicates the direction of the traffic flow. The following requirements are essential:

(i) The height of such a bollard should be about 1.2 meters above the ground level.

(ii) The bollard has a color combination of white, blue, and yellow. The area of exposure showing the directional arrow should be a minimum of 30 cm square (or of 30 cm diameter if it is circular). The remaining lower part of the bollard is canary yellow/traffic yellow.

(iii) The bollard should be illuminated inside by incandescent or fluorescent light.

(iv) As the bollard is vulnerable to accident, it should be made of a material such as plastic to avoid injuries.

A typically lighted bollard and its dimensions are given in **Fig. 5.14**.

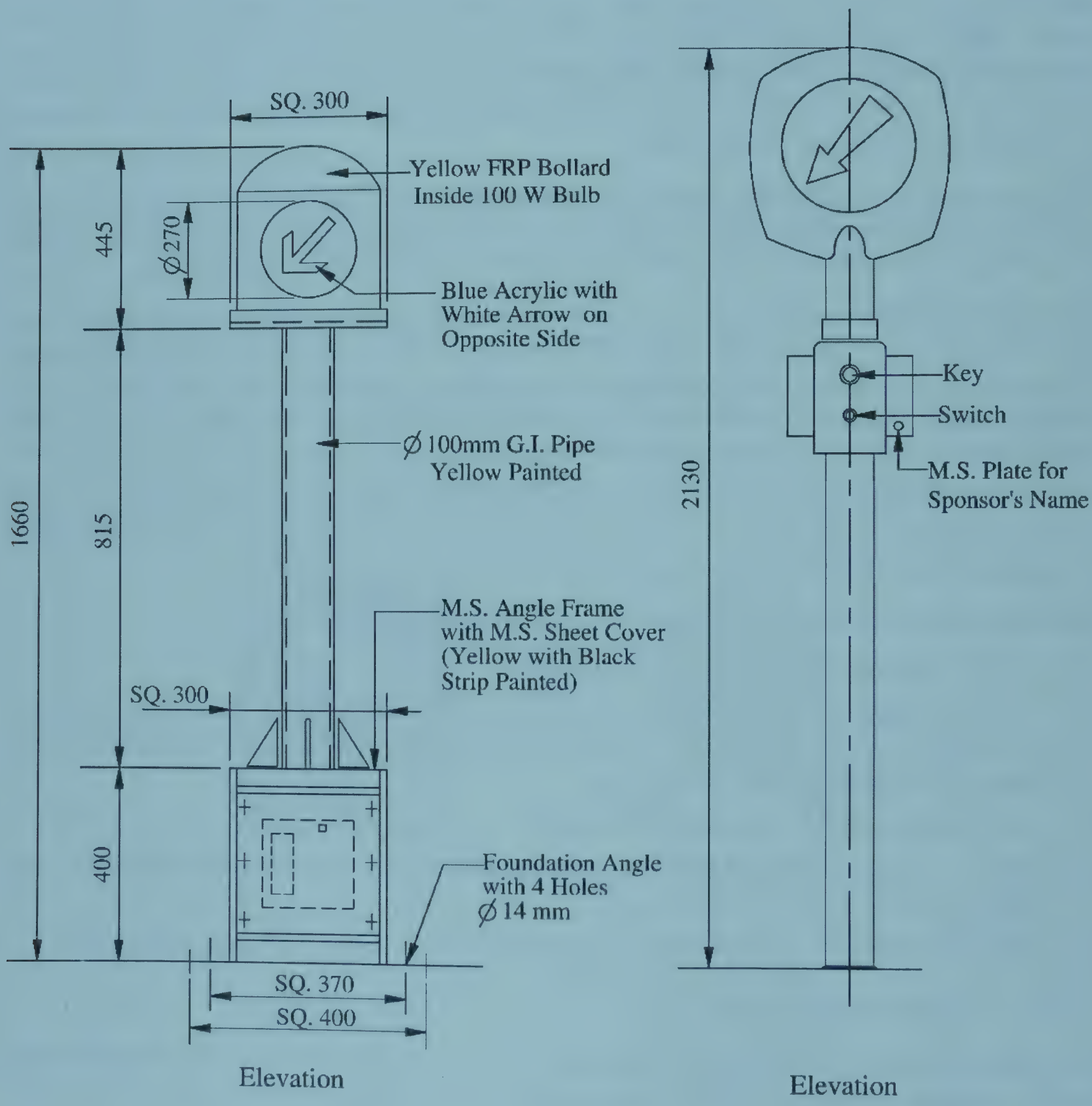


Fig. 5.14 Traffic Bollard (all dimensions are in mm)

6. TRAFFIC SEGREGATION

Traffic segregation techniques can be classified into three groups:

- Vehicle-Vehicle segregation
- Pedestrian-Vehicle segregation
- Time segregation

6.1 Vehicle-Vehicle Segregation Techniques

Segregation principles are being applied all over the world to separate the slow-moving traffic from the fast one, especially in the Central Business District. This can be achieved simply by imposing certain legal restrictions. The lorry traffic, wherever possible, is confined to the outer areas and restrictions imposed on their movements in the city limits during peak periods. On major roads where sufficient width is available, separate lanes are designed for fast and slow vehicles by using painted lines or physical dividers. In some cases, even the minimum and maximum speeds are also indicated. The following requirements must be borne in mind.

(i) Central dividers are not desirable on carriageways of width less than 18 meters, unless otherwise found essential for safety reasons. In any case, minimum carriageway width of 7.5 m on either side for facilitating 2+2 effective lanes, separated by a divider of minimum width of 1.2 m (i.e., total carriageway width of 16.2 m) must be available before considering the physical central dividers. Otherwise, continuous double lines be painted in the center. Median Markers highlighting the presence of central dividers/verge shall be provided to attract the attention of drivers and improve nighttime visibility

(ii) The physical central dividers are not recommended on bridges and flyovers, unless the width of the carriageway in each direction is 7.5 meters. It must be ensured that the effective carriageway width at the approaches is uniformly carried through the bridge/ flyover. However, continuous double lines should be painted to separate the opposing traffic; yellow paint would be more conspicuous.

(iii) The central dividers/verge should have adequate width so that it serves as refuges for pedestrians, persons on wheelchair and caregiver with pram to take shelter and can also accommodate other required road furniture such as signal and/or lighting posts.

(iv) Where an inadequate central verge is provided, it is desirable to do landscaping, so that glare of headlights is considerably reduced at night. However, while planting trees or shrubs, care must be taken such that trees do not obscure vision of drivers, especially near the intersections, pedestrian crossings and median opening. It is recommended that, at least 15 meters of the central verge from each end of the opening is kept entirely clear.

(v) Locations, where physical segregation of vehicles travelling in opposite direction becomes essential and concrete dividers, cannot be provided due to space constraints, it is advisable to have tubular markers installed on the double center line of the carriageway. **Photo 6.1** presents like example of the application of tubular posts.

(vi) Segregated cycle tracks should be provided on streets with vehicular speeds above 30 kmph. If cyclists have to be in mixed traffic street design should ensure speeds are controlled to 30 kmph.

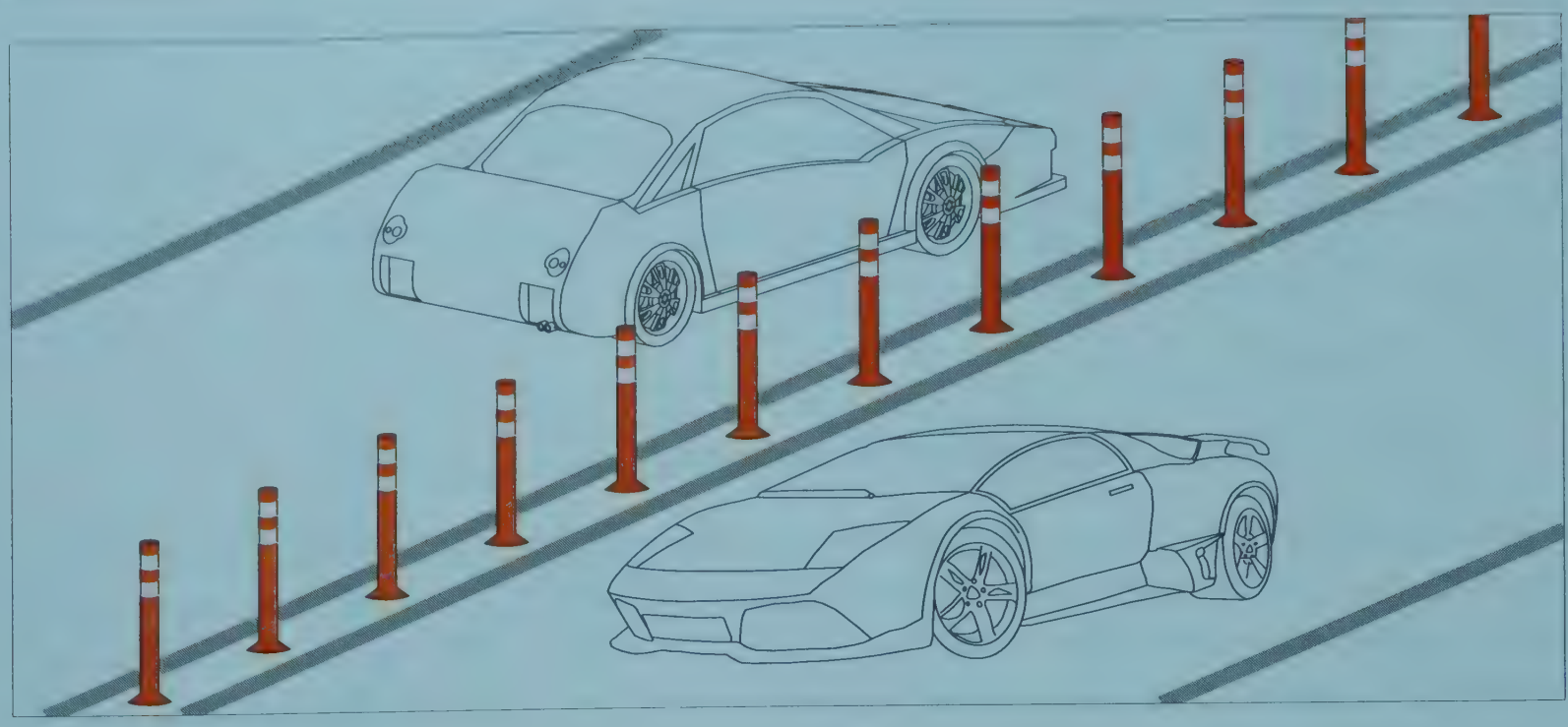


Photo 6.1 Application of Tubular Posts

6.2 Pedestrian Vehicle Segregation Techniques

It is a technique used to separate pedestrians from moving vehicles. The various techniques used under this are:

- Longitudinal segregation
- Lateral segregation
- Total segregation
- Spatial segregation

6.2.1 *Longitudinal Segregation*

(i) This mainly includes the construction of side-walks/footpaths. The specifications are given in IRC:103 "Guidelines for Pedestrian Facilities".

(ii) Raised footpaths are always preferable. However, wherever not possible, it is absolutely essential to segregate footpath from the carriageway by using guard stones and railings and it shall be retro reflectorized for nighttime visibility. Railings along footpath/central dividers are particularly important near the intersections so as to force pedestrians to cross only at the designated zebra markings.

(iii) Where pedestrians are expected to share the streets with motorized vehicles, such roads should be designed such that the vehicle speeds do not exceed 15 kmph.

6.2.2 *Lateral Segregation*

Lateral segregation is mainly done to ensure the safe crossing of pedestrians across the path of vehicles. It includes the following:

(i) Zebra Crossing: Refer IRC:35 "Code of Practice for Road Markings" for details.

(ii) Refuge island (discussed in para 5.4.5)

(iii) Railings along with central dividers: Such railings are provided on those roads where pedestrians tend to cross erratically, especially in congested areas.

(iv) Pedestrian Traffic Signals: Refer IRC:93 "Guidelines on Design and Installation of Road Traffic Signals" for details.

(v) Foot-over bridges

(vi) Pedestrian subways

(vii) Sky-walks

Grade separated facilities include pedestrian foot-over bridges, subways and skywalks. It ncreases pedestrian walking distance. Thus, pedestrians continue to cross at ground level at andom locations, increasing the chances of a road crash. Grade separated crossings should e provided on urban expressways or corridors where vehicle speeds are very high at about 30 kmph.

Pedestrian grade-separated facilities such as skywalks are used by pedestrians when integrated and connected directly at the same level with entry to transit stations, bus stops, and other mportant public buildings with minimum efforts. Where pedestrian grade-separated facilities are uilt, they should ensure universal accessibility and convenience to pedestrians by providing lifts, escalators and ramps for cyclists. They should be well-lit and ensure personal safety, especially or women and children.

A typical Raised Footpath, Foot-Over Bridge and Pedestrian Subway are shown in **Photos 6.2, 6.3** and **6.4**, respectively. The height of the raised footpath shall be constructed so as to make it accessible for all sections of society like old age people, children, disable etc. The guidelines for universal accessibility for urban road is given in IRC:SP:117.

Photo 6.2 Raised Foot Path

Photo 6.3 Foot-Over Bridge

Photo 6.4 Pedestrian Subway

6.2.3 *Total Segregation*

The ideal situation is, however, complete pedestrianisation. The streets with intense pedestrian pressure could be declared 'pedestrian only streets.' The restrictions on the movement of vehicles may be imposed either during the pedestrian peak time only, or throughout the day, depending upon the local situation. Where several such streets meet, the total area may be converted into "Pedestrian Only" area commonly known as 'pedestrian plaza' or "pedestrian precinct' or 'pedestrian mall.' The following points must be borne in mind while implementing such pedestrian schemes:

(i) The area should have a dense street network to provide multiple routes for pedestrians and alternate routes for vehicles. The area should be well connected with public transport. Pedestrianization should be done in consultation with shopkeepers, residents, and other relevant stakeholders. All facilities should be universally accessible and children friendly.

(ii) All such precincts must have an arrangement for easy access to emergency vehicles like fire-brigade, ambulance.

(iii) Goods vehicles must be provided reasonable access for loading and unloading during certain hours. Freight management plan is needed.

(iv) Adequate parking space must be available in the vicinity so that the walking distance is reasonable, and the business in the area is not adversely affected. Area level parking management plan is needed.

(v) Alternative routes are available for diverting vehicular traffic, thus displaced.

(vi) Bus service should not be adversely affected, and passengers must be brought within a reasonable walking distance. Some streets can be considered only bus and non-motorized transport streets. Non-motorized transport safety should be ensured.

(vii) The encroachments, particularly hawkers/vendors, are adequately checked by the authorities. A Vending management plan is needed.

(viii) The boundaries of pedestrian areas must be clearly demarcated and warning signs both for pedestrians and motorists conspicuously displayed on such boundaries to avoid confusion and improve safety. These warnings are expected to perform the following functions.

- Indicate to the pedestrian that she or he is leaving an area where he enjoyed complete freedom of movement or vice-versa.
- Inform motorists that they are entering a zone which permits them only restricted freedom of movement in terms of time, space etc.

It is, therefore, recommended that the entire pedestrian zone is created at a level different from the motorable roads and/or paved with special material so as to be prominent.

6.2.4 *Spatial Segregation*

There are spatial segregation techniques for cyclists, buses, etc.

(i) Bicycles tracks have been dealt within IRC:11, "Recommended Practice for the Design and Layout of Cycle Tracks". The cycle tracks and sidewalks should not be at the same level: a level difference of 10-15 cm is desirable in the interest of pedestrian safety. The boundary of the cycle track should be clearly marked with white paint.

(ii) Bus segregation is achieved through bus lanes and has only streets. Bus lanes and bus only streets are discussed later under "Bus Priority Techniques".

6.3 Time Segregation

Time segregation is meant to regulate the movement of vehicles by time of the day. For example, heavy freight vehicles are not allowed during peak hours in busy areas.

7. DEMAND MANAGEMENT TECHNIQUES

The planning and transport policies should not be based on completely unrestricted use of the motor vehicle. Emphasis needs to be laid on the management of the urban transport system to ensure the movement of more people in fewer vehicles in the least time while preserving and improving the environment. Therefore, the use of low-occupancy private cars, especially in the busy and congested areas, should be limited. This can be achieved through traffic restraint and demand management techniques that inhibit or restrict car use in the city Centre.

The underlying principle is that the benefit a road user obtains from a particular journey is more than the price that he would be prepared to pay in order to make the journey. But, if the price charged for making a trip was gradually increased, then the point would be reached at which the trip maker would either decide not to go, or to go by another mode of transport, or at another time. The principles of demand and supply become very relevant in this context. The demand for the use of road networks in a particular area can be curtailed by raising price, directly or indirectly, by levying taxes on the use of public roads and parking places, etc. In other words, those who are responsible for causing traffic congestion should be made to pay extra. Space efficient and less polluting modes such as walking, cycling, bus and public transport should be prioritized and use of private motorized vehicles should be discouraged to ensure efficient and equitable mobility.

Basically these restraint methods should be:

(i) Flexible, to meet differing and changing needs;

(ii) Efficient, so that undue restriction is avoided;

(iii) Selective, by type, area and time of journey;

(iv) Fair, and acceptable to the community at large;

(v) Inclusive to different socio-economic groups, gender, age, and persons with disabilities.

(vi) Simple, to administer and enforce, and not open to abuse;

(vii) Easy to understand and to follow for both casual and regular travelers.

Traffic restraint can be achieved by two methods:

- Indirect methods
- Direct methods

7.1 Indirect Methods

One of the major thrusts of the indirect methods is in the area of public transport options. The private motorists are encouraged to switch over to public transport by making the latter cheap, convenient, comfortable, readily available, and highly efficient. Simultaneously, restraints are imposed on the movement of personalized transport which may include:

- banning of a particular class of vehicles at a certain time and/or in certain areas;
- auto-free zones where vehicles are totally prohibited:
- special bus lanes and streets where space is reserved exclusively for public buses and emergency vehicles:
- Prohibition of entry and turns and limited access facilities.

Bus priority techniques along with restrictions on the movement of personalized transport through regulatory techniques, yield the intended results.

7.2 Direct Methods

The following techniques are considered under this sub-head.

- Parking controls and management
- Road and bridge tolls road pricing
- Regulatory controls such as "odd-even" schemes and its variants
- Staggering of office hours
- Congestion charging, through cordon pricing or area licensing/pricing

7.2.1 *Parking Controls and Management*

Parking plays an important role in ensuring that city communities have access to social infrastructure. Therefore, adequate parking spaces at community facilities and destinations, at appropriate times and appropriate locations should be provided. Parking should support events, festivals, exhibitions and concerts in the city through the provision of adequate parking spaces at appropriate times and in appropriate locations. This needs to be balanced with using public road space to encourage the use of sustainable transport to travel to and from these events.

Parking controls are the most widely used form of restraint in almost all the cities of the world. These may include on-street parking restrictions along major arteries, either 24 hours or during the peak time, depending upon the local conditions and requirements. Lately, on-street parking pricing is becoming very popular, as it not only achieves the objectives of reducing traffic congestion but also earns revenue which can be further invested in providing better walking, cycling and public transport facilities. It also ensures that car spaces are not misused by a few for garaging, but are put to optimum use for those who need them for the absolute minimum time. Some parking management measures like valet parking for off-street parking facilities also useful to reduce the congestion on the streets. Parking controls achieve the following:

- make efficient use of parking spaces:
- recover the cost of providing parking spaces and further invest in sustainable transport facilities;
- reduce congestion and prevent obstruction to moving vehicles;

The parking pricing is implemented through the following methods. Parking fees can be done according to zone, peak hour demand, weekdays and weekends, etc. by charging higher rates during peak hour with progressive increase in rates per hour (IRC:SP:12)

i) Off-Street Pay and Park Areas

Off-street parking is created either in the designated parking lots (however, election should be done intelligently) or by constructing special multi-story building or under-ground parking garages. Tariff Data is collected manually or by using electronic/ mechanical aids. However,

off-street parking facility will only be used if on-street parking is regulated and priced. Also on-street parking should be priced higher than off-street parking to discourage over use of on-street parking. Off-street parking facility should be only provided after implementing and evaluating the effects of on-street parking management. Valuable urban land should be first provided for social amenities and public spaces rather than parking which is the most inefficient use of urban land.

(ii) **On-Street Parking Meters**

Where off-street parking facilities are limited while the demand for parking is very high, parking meters may be installed along the kerb line of the roads where such parking would not hamper the traffic flow. Such schemes are generally implemented in commercial/shopping areas.

Cities should take two key steps for parking reform:

- Charge the right price for on-street parking to reduce the demand at high-demand locations, nudge vehicles to park in nearby but lower-demand parking locations, and eventually push parking into off-street market-priced private parking facilities.
- Control the supply of off-street parking through building- and area-level caps.

(iii) **Park-and-Ride System**

Large off-street parking areas are created to enable motorists to park their vehicles and switch over to the public transport like buses, trains, trams, etc. for onward journey to their work places, so that the traffic volume along major arteries leading to the Central Business Districts (C.B.D.) as well as the road network within the CBD is substantially reduced. Park and ride system should be only provided on public transport stations that are on the edge of the city and that do not have public transport facility. However, before building large off-street parking, it is recommended to first improve last mile connectivity through bus and intermediate public transport connectivity. This will discourage the use of private vehicles and reduce need for providing large off-street parking areas on expensive urban land.

Requirements: It may however, be remembered that motorists would tend to park on other roads in the vicinity of the area under parking control. In other words, they are likely to foul other roads and areas where congestion may consequently increase. It is, therefore, necessary for the parking charges to vary by zones. The parking charges should be higher in the city Centre with higher demand than in the neighbourhoods with low demand. Good parking enforcement is the pre-requisite of the success of this system, which may be ensured by employing traffic wardens, traffic policemen, towing cranes, etc.

Parking controls reduce the peak-period traffic and improve the general flow along such streets. As parking controls are not applicable for the through-traffic, the latter is encouraged to use such areas where movement has now improved. In other words, while the congestion may drop temporarily, the through-traffic from other areas is likely to be attracted to such roads. Hence, strategies like congestion pricing with target vehicle Kilometers travelled should be implemented along with parking management to effectively reduce motorized travel demand across the city.

7.2.2 *Road and Bridge Tolls*

Tolls are generally collected for the use of highways, bridges, tunnels and ferries. Most of these tolls are introduced to recover the cost of the facilities so provided. As alternative routes are

normally available to motorists, this technique imposes traffic restraint only to some extent and may not prove very effective as a restraint measure.

7.2.3 *Congestion Pricing*

Traffic Congestion refers to the incremental costs resulting from interference among road users. These impacts are most significant under urban-peak conditions when traffic volumes approach a road's capacity. The resulting congestion reduces mobility and increases driver stress, vehicle costs, and pollution (Congestion Costs). Traffic congestion is considered one of the main urban transportation externalities.

Congestion can be measured in various ways, including roadway Level of Service (LOS), average traffic speed, and average congestion delay compared with free-flowing traffic. The capacity of a road depends on various design factors such as lane widths and intersection configurations. Road Pricing involves charging motorists directly for driving on a congested road or area. Congestion Pricing is Road Pricing with higher rates during congested periods. It can reduce traffic congestion on a particular roadway, particularly if implemented as part of a comprehensive Travel Demand Management (TDM) program, for example, with Transit Improvements and Rideshare Programs. Road Pricing applied on just one roadway may cause traffic to shift routes, increasing traffic congestion on other roads.

Economists have long advocated Road Pricing as an efficient and equitable way to Finance and sustainable Transportation Programs, and encourage more efficient transportation. Congestion pricing is a tool to mitigate traffic congestion by charging an amount from vehicles that is sufficient to deter some, thereby decongesting the road(s) and improving the level of service for those willing to pay. While revenue generation can be a co-benefit of congestion pricing, the primary objective is to reduce congestion. The revenue generated should be utilized for improving walking, cycling, and public transportation facilities, along with maintaining the quality of existing roads to achieve equity. Road pricing categories given in **Table 7.1**

Table 7.1 Road Pricing Categories

Name of Policy	Description	Objectives
Road toll (fixed rates)	A fixed fee for driving on a particular road.	To raise revenues. Direct user change
Congestion pricing (time-variable)	A fee that is higher under congested conditions than uncongested conditions, intended to shift some vehicle traffic to other routes, times and modes.	To reduce traffic congestion.
Cordon fees	Fees charged for driving in a particular area.	To reduce congestion in major urban centers.
HOT (High Occupancy Tranport) lanes Or HOV (High Occupancy Vehicle Lanes)	A high-occupant-vehicle lane that accommodates a limited number of lower-occupant vehicles for a fee.	To favor HOVs compared with a general-purpose lane, and to raise revenues compared with an HOV lane. To effectively use road space and reduce congestion.

Distance-based fees	A vehicle use fee based on how many kilometers a vehicle is driven.	To reduce traffic congestion
Pay-As-You-Drive insurance	Prorates premiums by mileage so vehicle insurance becomes a variable cost.	To reduce various traffic problems, particularly accidents.
Road space rationing	Revenue-neutral credits used to ration peak-period roadway capacity.	To reduce congestion on major roadways or urban centers.

Congestion charging is a technique that requires drivers of certain categories of vehicles to be charged to use a congested corridor(s) at specified times (generally peak-period) in designated areas (generally the Central Business District). This technique, therefore, has an advantage over the parking control technique in as much that it affects moving vehicles as well. It is based on the principle that vehicles that cause congestion must be made to pay for it. Public buses, school buses and emergency vehicles are normally exempted from these restrictions as they have a small footprint compared to the number of passengers they carry.

The following requirements must be borne in mind while implementing such schemes:

(i) The area/corridor(s) in which restrictions are intended should be clearly defined by proper entry signs.

(ii) The restricted zone/corridor(s) must have the minimum entry points to reduce the cost of implementation

(iii) A mechanism to identify and charge the vehicles entering an area or corridor(s) should be in place.

(iv) This system requires good and effective enforcement so that drivers are not able to avoid charges to be paid.

(v) The design of the licenses should be such that it attracts immediate attention and cannot be easily forged.

(vi) Public acceptance of scheme especially where mixed land use of commercial and residences exist is necessary.

(vii) The road pricing can be varied with time of the day, but may be operational only during peak hours or high traffic volumes as per real time data.

(viii) A pre-requisite for the success of such road pricing technique is the availability of efficient, comfortable, cheap and convenient public transport system to enable the shift from private motor vehicles. This should be complemented with high-quality walking and cycling network.

Such techniques ensure that people either pool their vehicles, or use public transport, or change their journey routes or stagger journey time to avoid entry through the restricted zones/corridors. This in turn, reduces traffic congestion and accidents, and improves the environment besides saving precious fuel.

An even more refined version of corridor/ area-based pricing is network-based pricing, where a

vehicle is charged not by being captured at a series of gantries but through Global Positioning System (GPS) or similar technology that tracks its route in real-time. The congestion charge is applied for each road segment of the route, depending on the level of congestion on that segment. This evolving approach can be piloted with taxis which happen to be a fraction in number compared to private motor vehicles in many cities but contribute significantly to traffic since they are on the road most of the day. Further, taxis are already tracked in many cities (for online metering as well as passenger safety concerns). Therefore, implementation can be relatively easy and inexpensive.

The Global Navigation Satellite System (GNSS) is growing trend in Europe and Singapore for electronic road tolling. GNSS signals are provided by a variety of satellite positioning systems, including global constellations and Satellite-Based Augmentation Systems (SBAS). Various SBAS such as EGNOS (Europe), WAAS (North America), GAGAN (India) and MSAS (Japan) are already exists. The GNSS is efficient when road pricing is applied for large road network. This is one of the best solution to manage traffic at toll plazas also.

Tariff differentiation based on distance travelled, time of day, traffic volume, vehicle type and emissions are key factors for classifying schemes of congestion pricing. These schemes are also characterized as flat, scheduled, responsive and anticipatory, depending upon the degree of time differentiation. Various schemes implemented around the world along with their respective benefits are briefly presented in **Table 7.2**.

Table 7.2 Congestion Pricing Schemes Implemented in various Cities

Name of the City	Principal Objective	Scheme	Affected area (km^2)	Quantified Benefits
Singapore	• Congestion	Zonal Scheme	6-7	• 45.3% drop in traffic flow • 0.85% reduction in CO_2 emission
London	• Congestion	Zonal Scheme	21	• 30% reduction in congestion • 15% decrease in CO_2 emission • 6% increase in bus ridership • 12% increase in cycle journeys
Stockholm	• Congestion • Environment	Cordon Toll	34.5	• 20% decrease in congestion • 6-9% increase in transit ridership • 10% decrease in air pollutants • 20% increase in vehicle speed
Milan	• Congestion • Environment	Zonal Scheme	8	• 25% reduction in congestion • 4% increase in average speed • PM emission reduced by 23%

Norway	Generating Revenue	Facility Based Scheme, cordon Based Scheme	18(Bergen) 64(Oslo)	• Revenue earned • 70 million NOK (Bergen) • 880 million NOK (Oslo)
Trondheim	Generating Revenue	Cordon Toll	50	• 10% reduction in traffic

7.2.4 *License Plate Restrictions*

Some cities have restricted the number of vehicles that can be brought on the road on any given day of the week through license plate number restrictions. Popularly called the odd-even scheme **(Photo 7.1)**, the restriction could apply to 20% to 50% of the cars in the city. Such restriction may apply either the whole day or only during peak hours, across the whole city or in a designated area. The restrictions can also be imposed with reference to odd and even dates, instead of days of the week; Saturdays and Sundays are generally excluded because of lean traffic days.

Before Odd-Even Policy in Delhi

During Odd-Even Policy in Delhi

Photo 7.1 Odd-Even Auto Restrictions in New Delhi

These measures were successful when implemented, but the success was diluted in course of time when not augmented with additional measures. For example, in the case of Mexico City, number plate restriction was successful initially, but as time passed, more than one-fifth of the households purchased additional cars (usually cheaper, older, and more polluting) with alternating plates in order to circumvent the restriction.

In Santiago and Bogotá, the car ban schedule is changed every few months to prevent this possibility. In addition, in Bogotá, higher price of used cars reduced the possibility that this problem would arise. However, the implementation of such measures alone doesn't necessarily ensure effective demand control. License plate restrictions typically do not apply on taxis that are an important cause of congestion in cities worldwide, including India. A congestion pricing system, on the other hand, allows taxis as well as other vehicles to operate subject to the payment of congestion charge.

7.2.5 *Staggering of Office Hours*

It is one of the latest transport demand management techniques being used in various advanced countries. It envisages level or even out of peak-hours transport demand through the staggering of office hours (opening and closing times). As most offices and establishments open at about the same time, there is a heavy strain on the public transport and on the main arteries during peak hours. Therefore, the staggering of work hours for a longer period can help spread the peak-load and relieve the extreme overcrowding in buses, trains and trams, and congestion on the main arteries. Staggering does not reduce the total demand; it only evens out the demand to manageable proportions.

Though this technique is inexpensive and easily implementable, it is absolutely necessary to study the existing conditions and transport services schedules, their capacity limitations, origins and destinations of workers, their travelling times, the inter-dependence of various types of establishments, the need for certain core hours when all establishments should be working at normal full strength, their geographical locations, etc. The success of this scheme entails voluntary cooperation of the employers and the employees.

8. BUS PRIORITY TECHNIQUES

The priority for buses is mainly related to movement of people as opposed to movement of vehicles. The road space should be allocated to the competing transport modes on the basis of demand and their efficiency in terms of passenger carrying capacity. The main objective is providing protection to buses from delays which are associated with traffic congestion. The bus which is delayed by congestion will find more passengers waiting at bus stops and will continue to lose time. The following bus will find fewer passengers at the stops and may, therefore, overtake the first one resulting in the familiar phenomenon of bunching. Consequently, the service on the whole line is disrupted. It is, therefore, necessary to accord priority to buses so as to make the public transport more efficient and attractive with a view to discouraging private motorists from bringing their personal vehicles on to roads, especially during peak time.

The following techniques are generally used to provide the desired priority:

- Priority manoeuvres;
- Bus lanes;
- Bus precincts;

8.1 Priority Manoeuvres

It is a simple technique to give priority to buses by permitting them turning movements which are prohibited to other vehicles. This is often used as a part of one-way scheme or in conjunction with contra-flow bus lane. However, this technique entails better enforcement so as to ensure that other vehicles do not violate thereby defeating the main objective. It is, therefore, necessary to fix sign-boards prominently, indicating, for example 'Right turn only for Buses'. It is also advisable to paint "Bus only" along with the right turning arrow on the carriageway.

8.2 Bus Lanes

Bus lanes are the most common form of bus priority techniques, when road space is set aside for buses either at a particular time or at all times. Such lanes can be either with-flow or contra-flow.

8.2.1 *With-Flow Bus Lane*

A with-flow bus lane, **(Fig. 8.1)**, is one where buses move along the direction of traffic. Such a special lane is created when a part of the road is exclusively reserved for buses. It is usually reserved along the kerb side, and in the centre in special circumstances. The central reservation is generally done on freeways/expressways where bus stops are not frequent as the passengers are highly exposed to traffic in such lanes. Therefore, on arterial roads, where bus stops are frequent, reservation is made near the kerb side. Such bus lanes are usually in operation only during the morning and evening peak hours. These special lanes are sometimes made available to other High Occupancy Vehicles (HOV) as well, such as cars with minimum of three persons, contract and school buses and emergency vehicles. This however, depends on the local conditions that vary from city to city. Such lanes are normally provided only if the frequency of buses is at least 60 per hour and number of passengers moved by these buses is at least 1.5 times the number carried by other vehicles in the same direction.

Associated problems: On narrow roads and have a lot of mixed traffic, commercial establishments, taxi and auto-rickshaw stands, with-flow bus lanes may not prove a success. However, where bus frequency is very high and express bus service is also operative, such lanes may prove counterproductive, as boarding and alighting at a bus stop may hold all buses behind unnecessarily. It is also very difficult to shift all taxi/auto-rickshaw stands to by lanes. As various encroachments, excavations, garbage dumps and other such impediments force pedestrians, many a times, to move on the carriageway, not only such bus lanes may not prove very useful but are also likely to pose safety hazards. These lanes may also curtail substantially the space for other vehicles on the carriageway, thus creating artificial traffic jams. The success of such special lanes presupposes good enforcement and would, therefore, call for large deployment of enforcement personnel all through the lane. The other problems may be:

a) problem related to deliveries, thus inviting protest from traders and shopkeepers;

b) problem of turning movements at intersections;

c) delay at the stop along the lane when it is being used by several buses sharing the same stop.

8.2.1.1 Introduction Requirements

(i) Availability of minimum two effective lanes (each 3.5 m wide) in addition to the reserved lane (minimum 4 in width);

(ii) Painting single continuous white lines (each 25 cm wide) to delineate the boundary:

(iii) Painting of bus symbol and arrows to conspicuously indicate the lane “buses only”;

(iv) Time of operation to be indicated on the lane;

(v) Sign—boards to be displayed prominently all along the lane, indicating the specific time of operation; and

(vi) Installation of red flasher lights at important junctions, especially where the lane is being discontinued (either for some distance or completely), and amber flasher at the beginning/intermittent entry points.

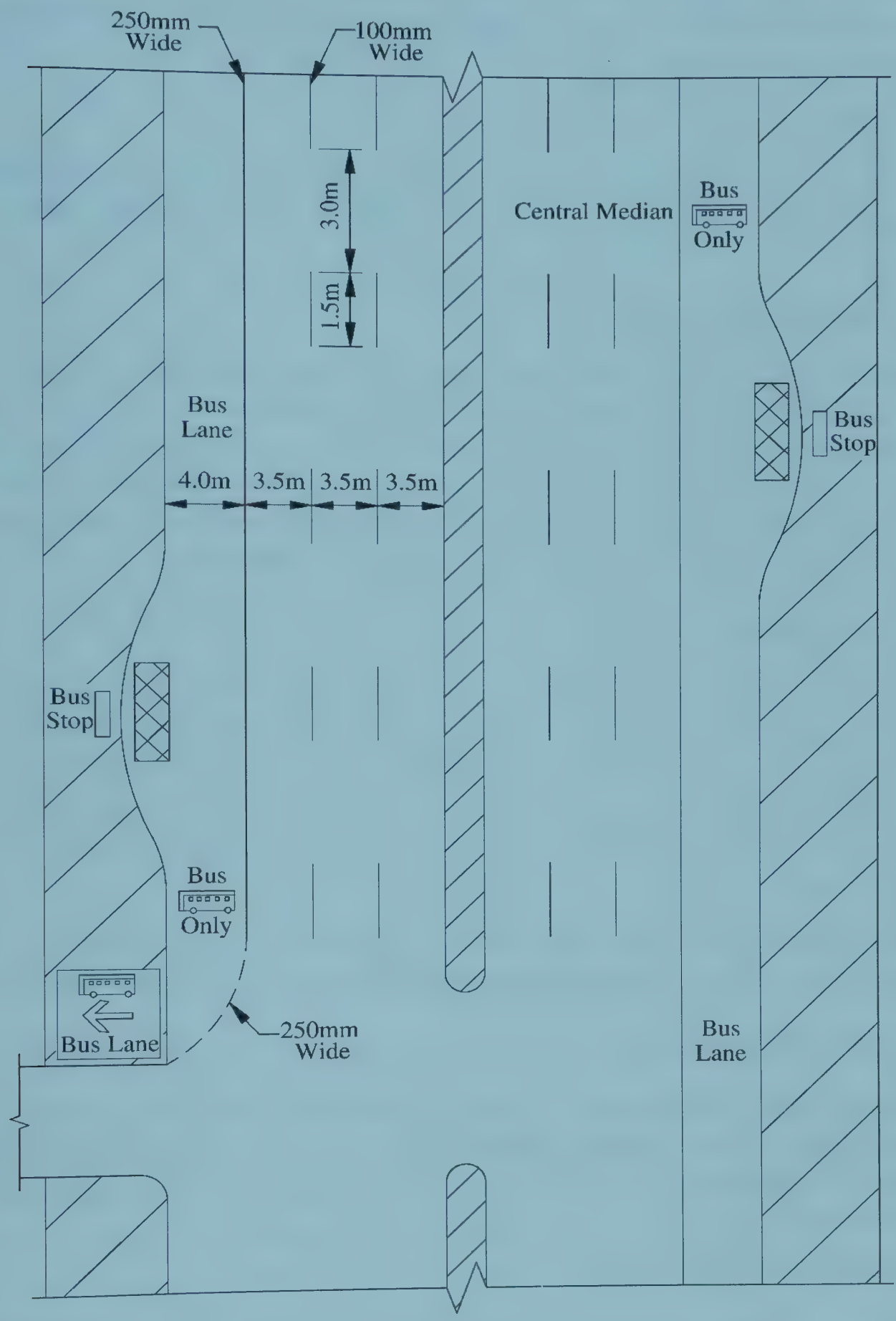


Fig. 8.1 With Bus Lane

8.2.2 *Contra-Flow Bus Lane*

t is a lane on a one-way road, solely reserved for buses that are permitted to drive against the low of other vehicles so that direct route of buses is not hampered by the introduction of the one-way system and commuters are not inconvenienced.

The contra-flow bus lane, **(Fig. 8.2)**, should not be less than 4 m wide. Such bus lanes are usually in operation for 24 hours to avoid confusion. All other requirements are the same as spelt out in case of with- flow bus lanes. Contra-flow bus lanes are generally introduced only when flow exceeds 30 buses an hour. They are also made available to emergency vehicles and sometimes even to school buses.

8.2.3 *Reversible Bus Lane*

It is a with-flow bus lane that is provided in the centre and is used in the appropriate direction depending upon the direction of the peak-flow. During the non-peak period, this lane is used as a turning lane.

8.2.4 *Central Median Bus Lanes*

Central median bus lanes is recommended over kerb side bus lanes in Indian context. The kerb side is frequented by on-street parking, auto-rickshaws and taxis for alighting and boarding, loading/unloading facilities and on-street vending activities which creates friction for bus movement. Kerb side bus lanes require very high level of enforcement and no friction for better performance. Also with heterogeneous traffic conditions, often kerb side bus lanes can be misused by two-wheelers and auto-rickshaws due to lack of discipline.

8.3 Bus Precincts

Bus precincts are 'bus only streets' also known as 'bus malls'. These are normally introduced in city centres where pedestrian anti bus activity is very high. Access to such streets is permitted only to buses, emergency vehicles and pedestrians. The remaining traffic is normally diverted through other roads. Parking lots are created at the periphery, with access only through side lanes, so as to facilitate drivers to leave their cars in parking areas and take lift in buses (known as park-and-ride system).

The introduction requirements are mainly proper signage and lane markings. Central refuge islands should also be considered for helping pedestrians cross the carriageway safely.

8.4 Bus Priority Signal System

Traffic signals account for a major part of delay on urban streets. With a view to promoting the public transport system, they may be accorded high priority by suitable modifications of the signals system so that there is minimum delay at intersections. This can be achieved through the following two methods:

(i) Bus pre-emption technique

Bus pre-emption is achieved by fitting transponders on buses and receivers on traffic signal controllers. When a bus approaches a signal, the transponder sends a signal which is detected by the loop-detector' in the carriageway. This detector, in turn, communicates with the signal controller which either terminates the cross-flow early or extends the running green on the approach to enable the bus to clear the intersection. To prevent traffic queues building up on side roads, an additional running time can be subsequently allocated to them when no bus is present on the main road, thus restoring some of the time lost to other traffic. Such priority can be extended to even emergency vehicles.

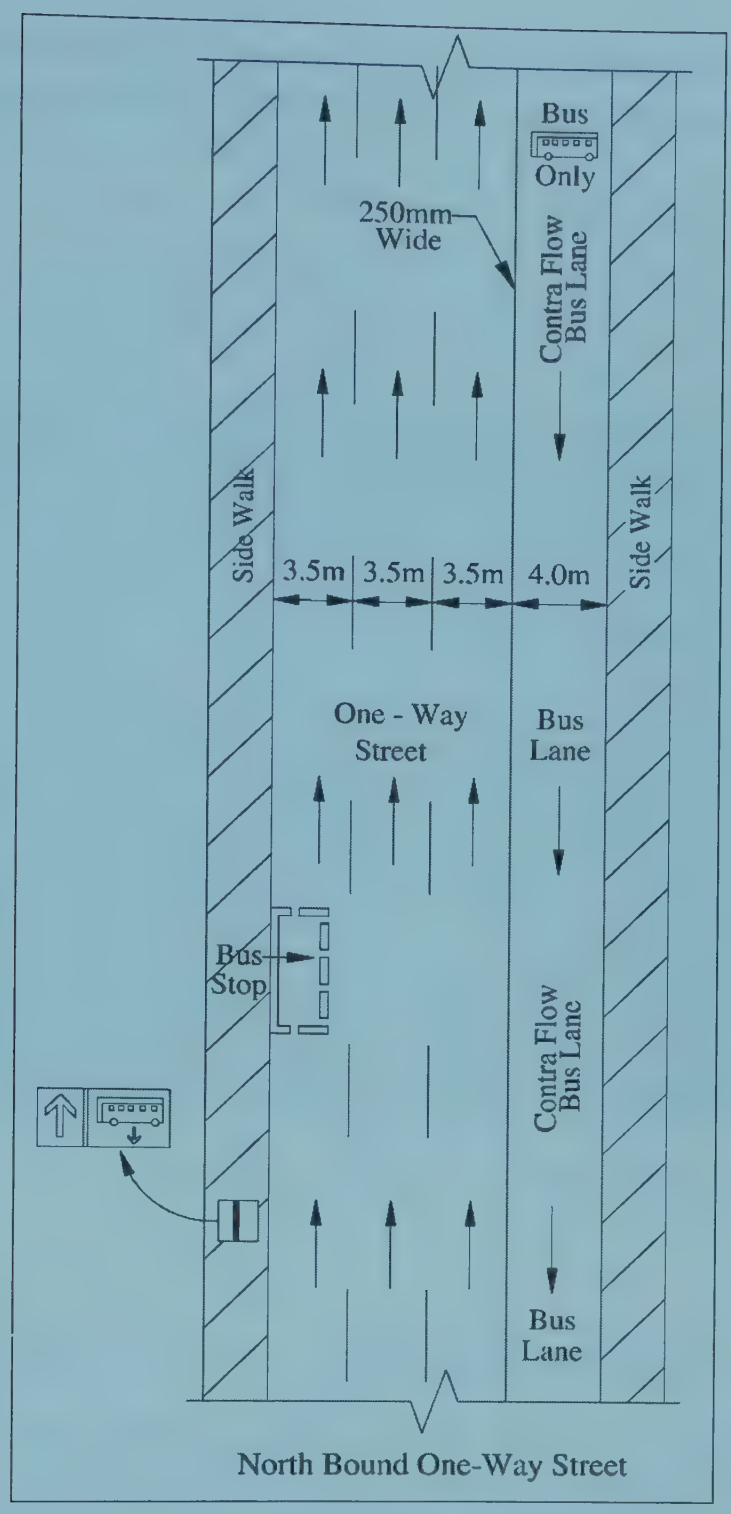


Fig. 8.2 Contra Bus Lane

ii) Co-ordinated traffic signals system

As buses have to halt at various stops between the signals and the halting time keeps varying, hey can rarely take advantage of the co-ordinated signals systems. To overcome this problem, a computer software has been developed to optimise the signal settings to minimise delay to buses throughout the control network. This programme takes into account the variation in bus ourney time (compared with other Vehicles) along each link and the time spent at bus stops on hat link. Accordingly, the priority is accorded to buses.

n the signal system that is not vehicle-actuated, the fixed time signal can be so designed as to give preference to the link having the maximum bus routes. Another solution is to provide bus sluice (an empty lane from the end of bus lane to intersection stop line). The said empty lane s usable only by buses so that they can go ahead without getting caught in the traffic queue t the intersection. Naturally when the signal turns green, buses would be the first to cross the ntersection.

Though the bus priority signal system is not strictly low-cost, it is certainly cost-effective and can improve the overall efficiency of the public transit vehicles by 10 to 30 per cent.

8.5 Bus Operations Management System

The bus operations management techniques can also be very useful in improving the public bus efficiency on important links. Such techniques help in reducing the waiting time at ticket counters and bus stops, time for getting in and out at loading/unloading points, besides minimising the chances on bunching of buses, especially during the peak hours, along major routes. This ultimately reduces delays at intersections and stagger the bus load uniformly in the entire network. Some of bus operation management techniques are given below:

- bus stops resisting
- bus-routes modifications
- bus-schedule modifications
- shuttle bus services
- express bus services (limited stops)
- point to point service
- special buses for women
- park-and ride facilities
- simplified mode-transfers
- simplified fare-collection
- luxury bus services
- chartered bus services
- real time information on location of buses

In India besides BRTS, Bus Priority lanes were implemented in India to improve the bus transportation system and ridership. In the year 2019, Bengaluru Traffic Police (BTP) and Bangalore Metropolitan Transport Corporation launched Bus Priority Lane in part of Outer Ring Road Bangalore. To impose this, BTP has decided to have traffic fines for private vehicle drivers on violating Bus Priority Lanes. The corridor has seen a 22% improvement in bus speeds along the corridor. The combination of reduced travel time and increase in service supply has resulted in a significant increase in bus ridership along the corridor.

9. SELF-ENFORCING TECHNIQUES

Financial constraints and administrative difficulties restrain the use of manpower and modern equipment to the bare minimum. Therefore, it is necessary to evolve simple engineering and management techniques that can ensure traffic discipline automatically. The self-enforcing techniques make the enforcement easier and simpler, thus optimising the use of manpower and eliminating/minimizing the need for modern/specialized equipment. Some of these techniques are listed below:

9.1 Central Dividers

Dividers are usually provided to earmark the segregated movement of a particular type/category **(Photo 9.1)** of traffic, such as, segregating through carriageway from a service road for local

traffic, segregating light and heavy traffic, segregating through traffic from turning traffic and dedicated BRT corridor and corridors for non-motorised transport (cycles, rickshaws etc.). The dividers can be within the form of low height central verge, curb, railing, etc. which can be either permanent (steel, concrete etc.) or flexible/ movable, shiftable such as rubberised cones, precast curbs and electrically/ mechanically operated shiftable divider railings. Central dividers on wide roads ensure that vehicles confine their movements only to the correct carriageway, thus avoiding any conflict with traffic from the opposite direction.

Photo 9.1 Central Dividers

9.2 Railings

The railings over central dividers **(Photo 9.2)**, or along footpaths, ensure that pedestrians do not cross erratically or spill over the carriageway. Places where considerable pedestrian traffic is expected, railing in the median of the road and reinforced concrete crash barrier is provided separating the vehicular and pedestrian traffic. For rigid railing, the strength should be equivalent to that of rigid RCC type. For areas of low intensity of pedestrian traffic, semi-rigid type of railings, such as concrete, steel, etc. can be adopted.

Photo 9.2 Railing

9.3 Parabolic Dividers

Parabolic dividers and flower-beds which have a height of nearly 1m ensure pedestrian discipline in built up area/ markets. As the railings in the middle of roads are vulnerable to accidents, parabolic dividers and flower-beds serve the same purpose more efficiently, besides improving the environment. This also restrict the effective carriage way. In certain areas where wide space is not available for central verge, narrow concrete curb is useful and may be provided. The concrete curb is usually in the shape of parabolic divider **(Fig. 9.1)**.

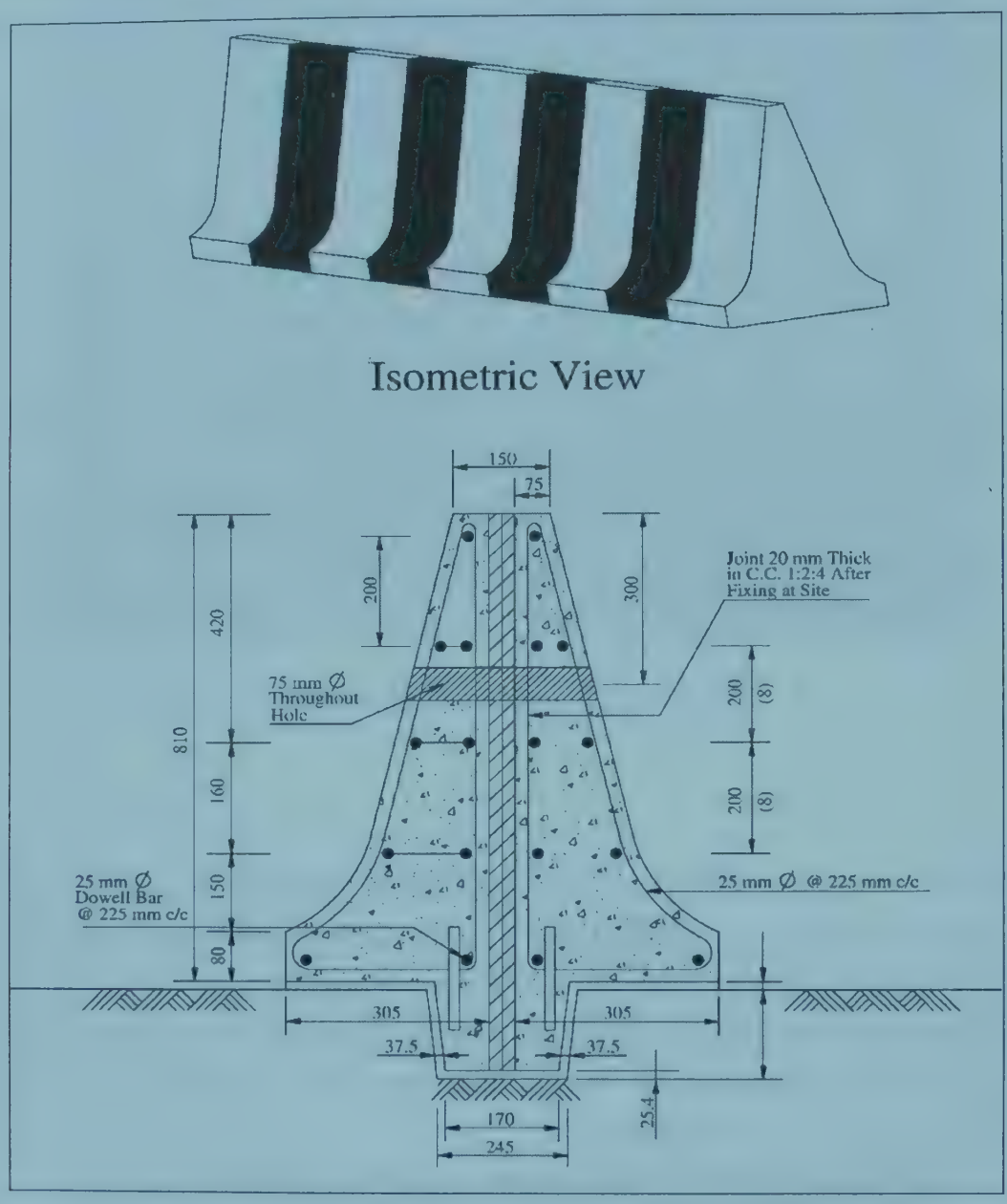


Fig. 9.1 Parabolic Dividers

9.4 Channelisers

Channelisers at intersections **(Fig. 9.2)** ensure safe turning movement and proper lane discipline. Specially designed channelisers may be used at those corners where certain turning or movement restrictions are to be imposed. Refer IRC:SP:41 for details.

The objectives of providing channelizing island are to:

(i) Control speed and path of vehicles at the intersection;

(ii) Control angle of conflict;

(iii) Separate conflicting traffic streams;

(iv) Provide shelter to vehicles waiting to carry out certain maneuvers;

(v) Assist pedestrians to cross;

(vi) Reduce excessive carriageway areas and thus limit vehicle paths; and

(vii) Locate traffic control devices.

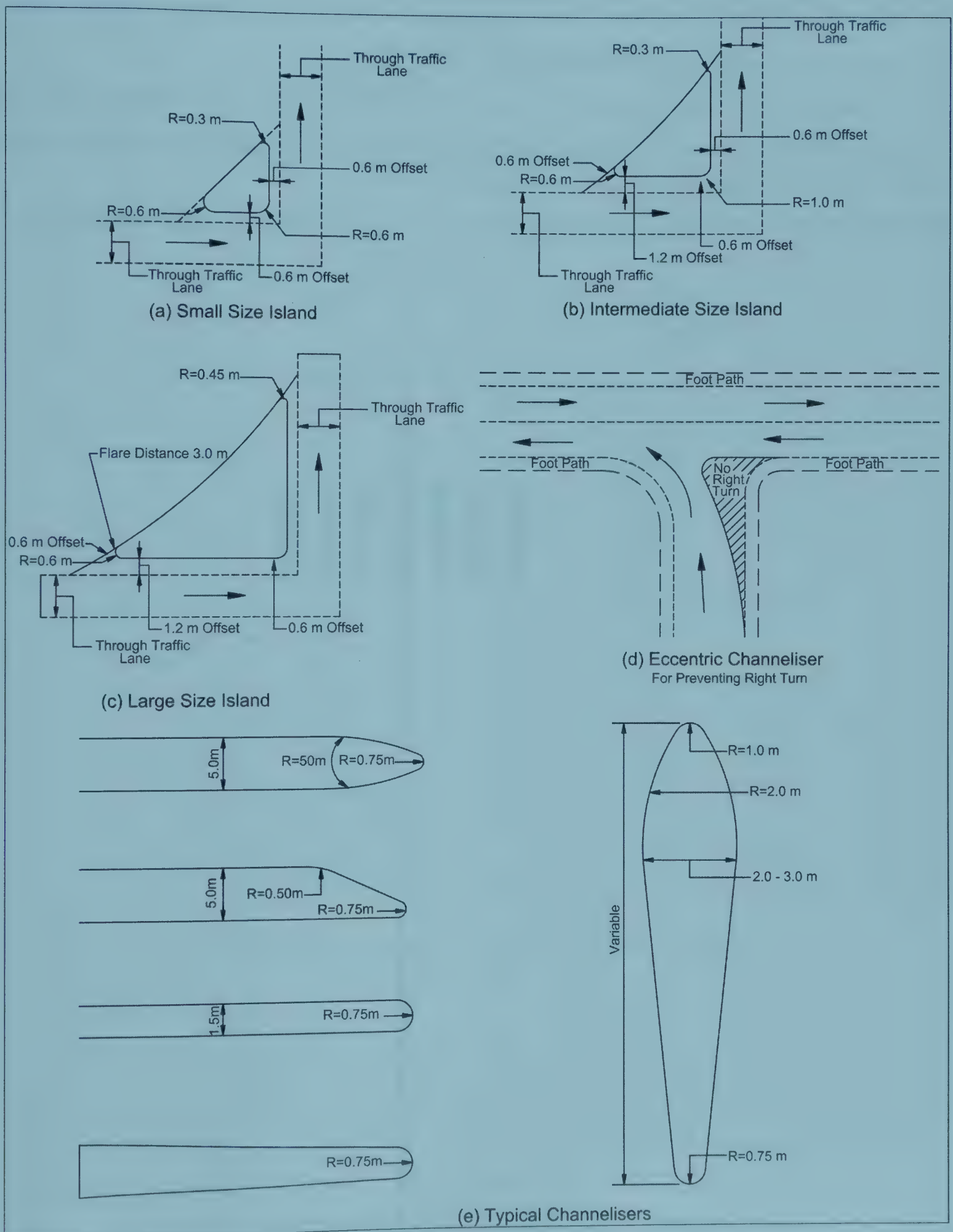


Fig. 9.2 Some Typical Channelisers

9.5 Queue Channels

To ensure taxi queue discipline at airports, railway stations, hotels, cinema theatres, and othe such important traffic generators, it is desirable to delineate the queue channels by the use o raised kerbs to achieve the following (**Fig. 9.3**):

- No unscrupulous taxi driver can jump the queue to pick up passengers out of turn.
- The taxi queue does not interfere with the main traffic.
- The passengers are given a specific area for boarding & alighting to ensure their safety.
- Unless the first taxi moves, another taxi behind cannot. It would automatically ensure tha no taxi refuses passengers for short distances.
- Only one police constable at the head of the queue can ensure proper discipline.

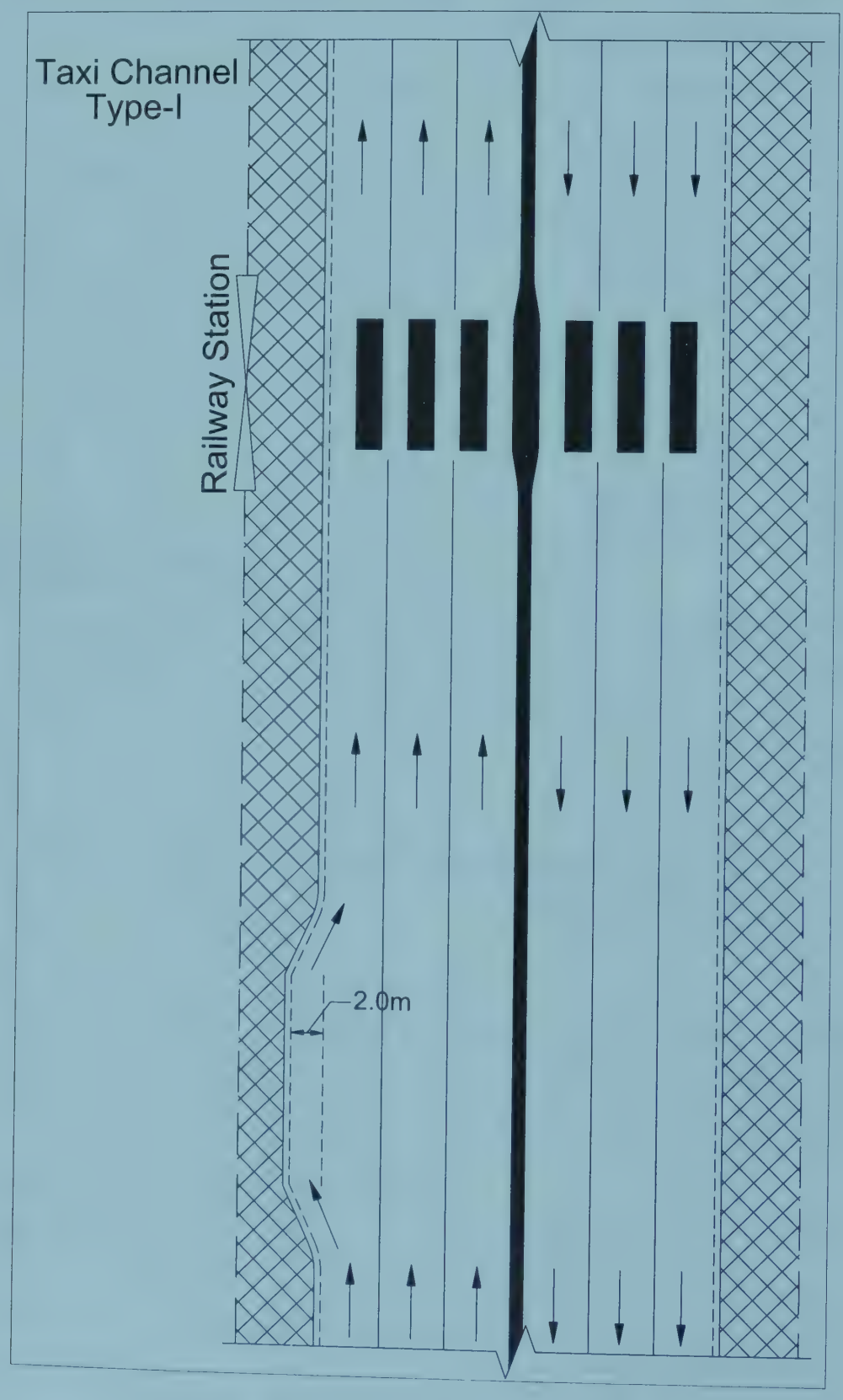


Fig. 9.3 Taxi Channel

9.6 Parking Notches

Wherever footpaths are very wide while the parking demand is high, the authorities may consider permitting angular parking by providing notches in footpaths (**Fig. 9.4**) to ensure orderly parking and in-out movements, Parallel parking should be preferred over angular and perpendicular parking. In angular and perpendicular parking, a blind spot is created as a driver cannot see the approaching traffic. This creates friction while reversing the car and affects the traffic flow.

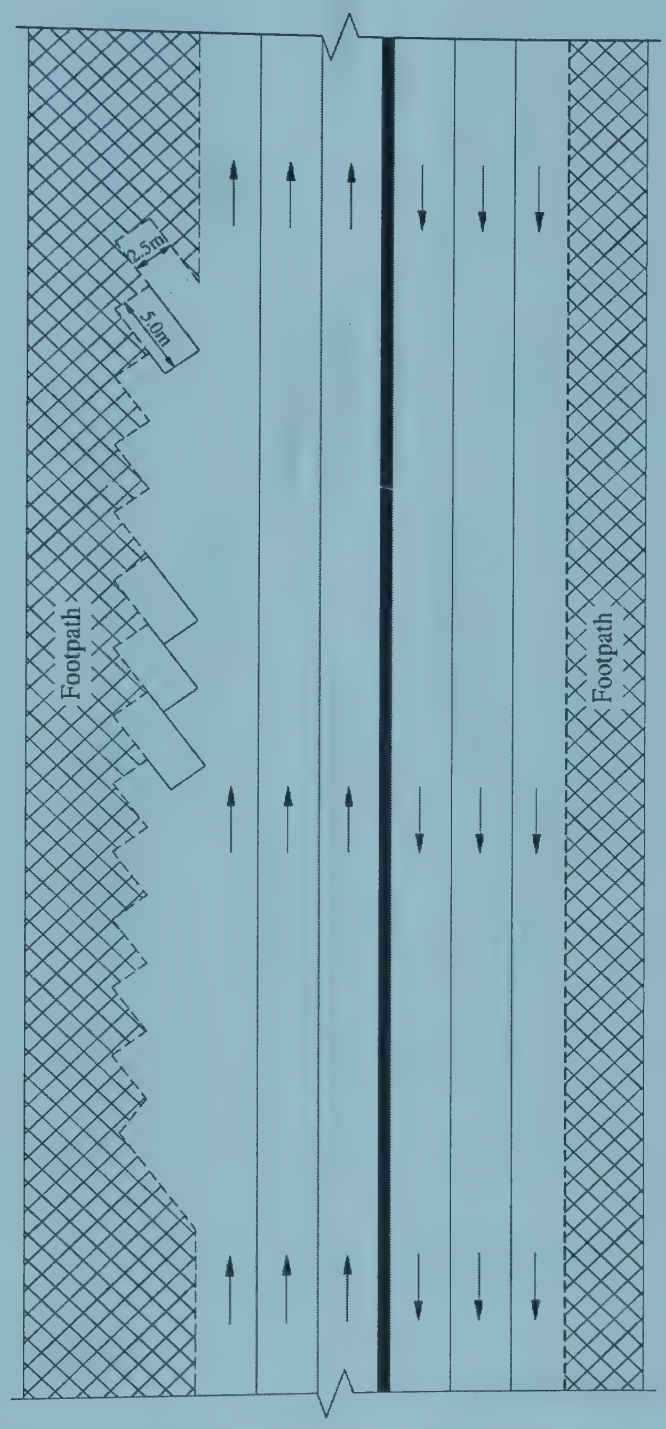


Fig. 9.4 Design Notch for Angular Parking

9.7 Chicane

To avoid speed-breakers which are normally detected by most motorists, artificial bottlenecks can be created at such locations. Such bottlenecks, also are known as "Sleeping Policeman", (**Fig. 9.5**) can be in the form of convex protrusion of footpaths. These are provided generally in the residential areas where the traffic is mainly local. It serves the following functions:

- helps pedestrians as they have to cross shorter width;
- commands respect from drivers as they cannot afford to be fast;
- continuous parking nuisance is eliminated.

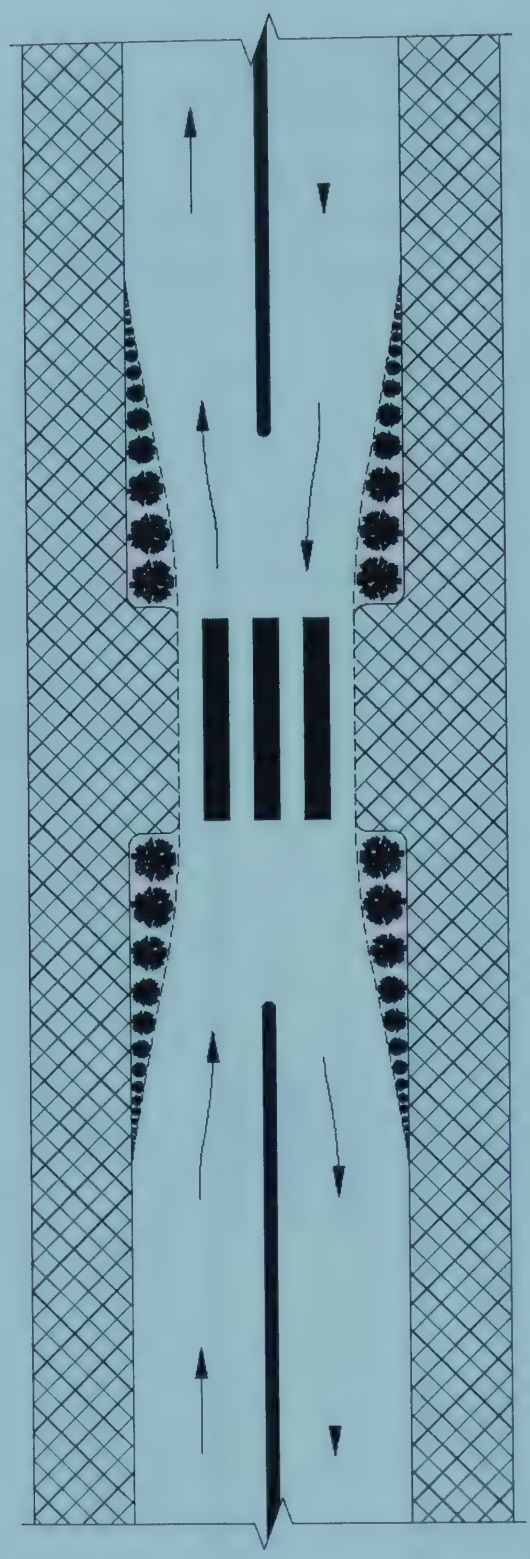


Fig. 9.5 Sleeping Policeman

9.8 Bus Bays and Bus Bulb-outs

Bus bays are useful for proper marshaling of buses to the bus stop without interfering with the main traffic flow on the carriageway. The width of such bus channels should not be less than 3 meters, delineated by a painted white strip. Where space permits, bus bays should be segregated by constructing raised dividers/islands. However, lighted bollards must be fixed at the mouth of such bays on the divider to fore-warn other motorists. The lay-byes (setbacks off the carriageway) are preferable. Where adequate space is not available for constructing a lay- bye, bus boxes should be painted in white for the guidance of drivers and commuters (**Fig. 9.6**). It will automatically ensure that commuters do not spill onto this channel area and confine themselves only to the bus stops. The lay byes should conform to IRC: 70 "Guidelines on Regulation and Control of Mixed Traffic in Urban Areas". While providing bus bays, it should be ensured that footpath space is not compromised. Continuity of walking is to be ensured.

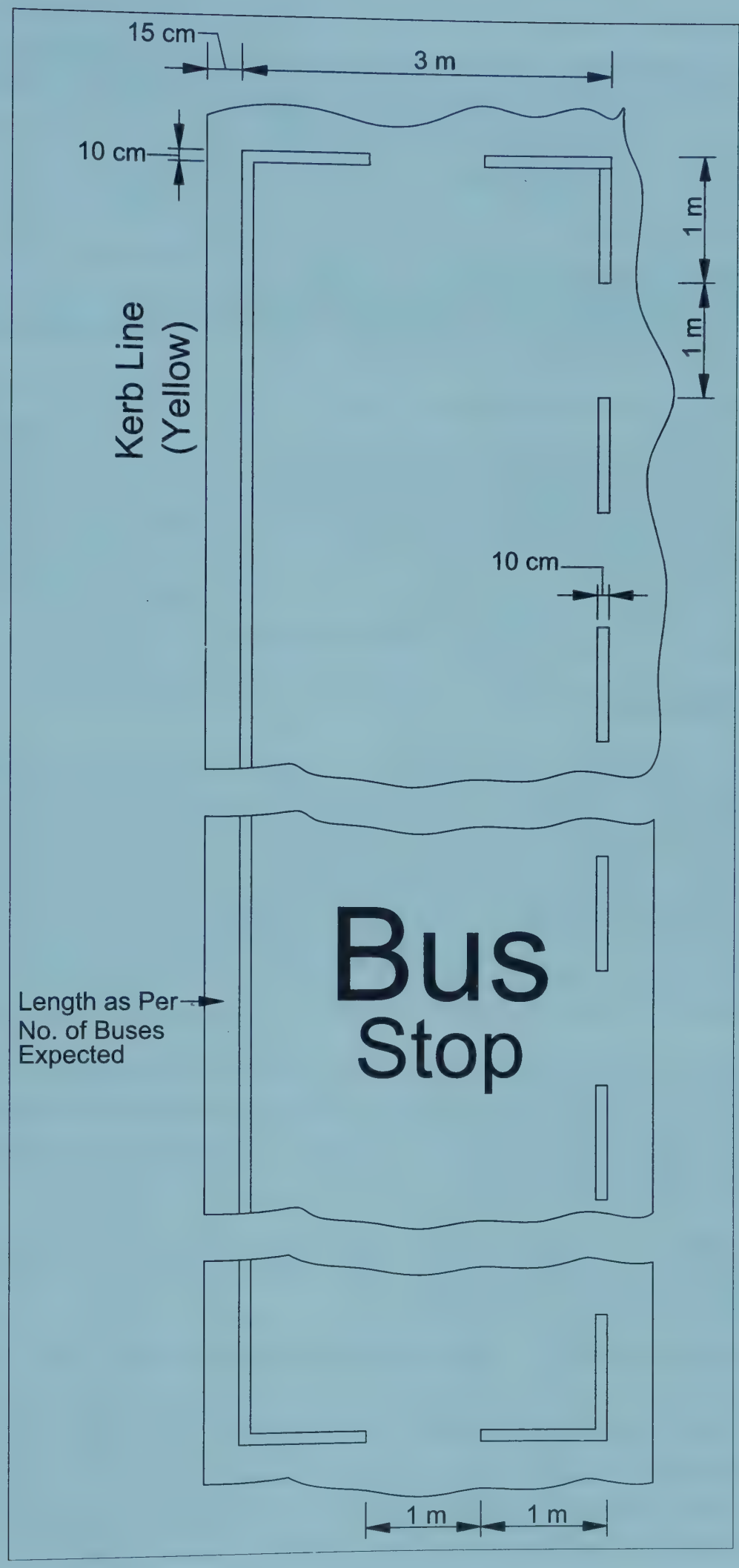


Fig. 9.6 Bus Stop

Bus Bulb-Outs: Bus Bulb-outs are curb extensions which allow buses to stop in the lane, hereby eliminating to re-enter the traffic flow. These were adopted globally in various cities. A ypical bus bulb-out is shown in **Fig. 9.7**

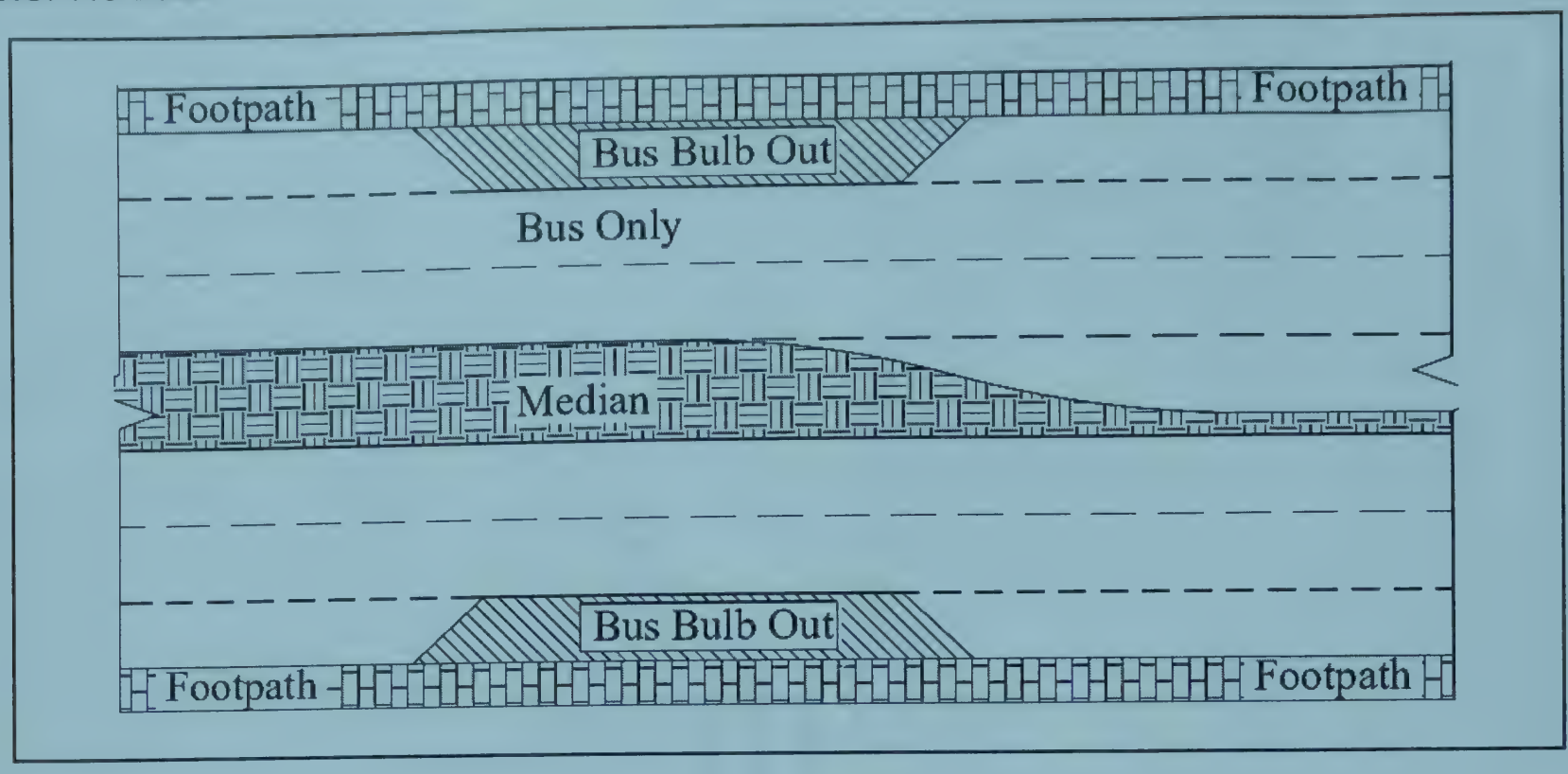


Fig. 9.7 Bus Bulb-out

9.9 Share-a-Taxi System

This system envisages a point-to-point service from an important traffic generator to a common destination. In this scheme, a taxi carries four persons on a tariff computed based on normal fare divided by three. In other words, while each passenger pays only one-third of the normal fare, the taxi driver gets about 33 percent more. Naturally, the chances of refusal to ply over a short distance or charging excessively, etc. are almost eliminated. Moreover, such taxis function as intermediate public transport, reducing the load on public buses and utilizing the taxi occupancy to its optimum. Besides, this system would increase the supply of public transport systems.

The auto-rickshaws can also be covered by such a scheme, carrying three passengers. Total fare, comprising normal fare increased by 25 percent is divided by three to work out the tariff payable by each passenger. This system, in a slightly different form, is operating in some of the cities like Surat, Jamshedpur, Indore, etc.

In large cities, this system can also benefit ladies who can form their own group for taking a common ride that makes them feel secured.

Such a scheme should be worked out in close association with the taxi/ auto-rickshaw associations after conducting a survey of the areas so that there is enough clientage for a particular route. The waiting time should not exceed five minutes, which means four passengers must be available every five minutes so that the scheme along that route is successful. It is equally necessary to provide general taxi/auto-rickshaw stands in the close vicinity of the share-a-taxi stand so that passengers have a choice.

9.10 Fixed Tariff System (Pre-paid Service)

At the airports, railway terminals. etc., there is a tendency on the part of taxi drivers to exploit passengers by overcharging or taking them through longer routes or refusing to ply over short distances, or fleeing passengers by other means. It naturally causes serious enforcement burden

and the need for deployment of traffic police personnel to check such activities. It is therefore, desirable to introduce the following system. The entire city can be divided into various zones and the normal fares for the maximum distance in these zones are calculated. For the first zone. about 100 percent extra incentive in the fare so calculated is given and the incentive for the subsequent zones is successively reduced; 30 per cent - 40 per cent being the incentive for the last zone. These incentives ensure that taxi-drivers are not tempted to indulge in malpractices and do not refuse plying over a short distance after long waiting at the queue. The incentive amount offsets the waiting time.

A ticket counter is set up where the passenger buys a ticket for his destination zone at a fixed rate. His name, address and destination are recorded in the register and cab number is written on the receipt handed over to him. This receipt is countersigned by the passenger after reaching his destination. The taxi driver collects the fare from ticket counter by producing the countersigned receipt. The details of both the driver and passenger are available now with the traffic police. It ensures that, in the event of a problem or crime, the passengers/drivers can be immediately traced. It acts as a psychologica! deterrent to unscrupulous taxi drivers and provides a sense of security to the passengers. There is no monetary exchange between the driver and the passenger.

A token amount is charged as a part of the fare payable to the taxis as service charge. The amount so collected helps in the operation and maintenance of the ticket counters. Good signboards are absolutely necessary to inform passengers about this system. They should also indicate various destinations and the chargeable fare. Warning boards should also be displayed advising passengers not to hire a taxi from any other place.

9.11 App-Based Taxi Services

Commercial Transport Apps (CTA) based services are rapidly gaining in India. They are easy to use and allocate spare transport capacity more efficiently than traditional for-hire providers. The CTA based taxi services are widely used in densely populated cities in India where parking issues are more. These cab services are providing security through GPS technologies and woman taxi drivers for woman passengers during night times. These services are also providing share auto, Bike share services etc. The booking app linked with Google map. These apps allow to choose to pick up and dropping location. These apps also allow available rides such as Car, Bike, Auto etc.

Helsinki introduced the smart phone based Mobility as a Service (MaaS) multimodal planning app. This will useful to control private vehicles on roads. The main objective of implementation of Maas is to encourage people to refrain from driving when wide choice of transport modes are available, the transport choice includes are public transportation, 2- wheeler, car and bicycle

10. PUBLIC INTERACTION TECHNIQUES

Traffic management scheme can hardly be successful without the active participation and acceptance of the public. Voluntary cooperation is essentially the first stage of public interaction, as it creates an environment where the road user is taken into confidence by the administration,

10.3 Variable Message Signs (VMS)

VMS can be effectively used for relaying variable messages to keep the public not only informed of various traffic innovations but also to give those interesting facts and statistics so that their curiosity is maintained. VMSs are electronic traffic signs often used on roadways to give travellers information about special events. Such signs warn the road users of traffic congestion, accidents, incidents, roadwork zones, or speed limits on a specific highway segment. VMSs as shown in **Fig. 10.4** may suggest the road users to take alternative routes, limit travel speed, warn of location of the incidents or just inform of the traffic conditions. A common technology used in new installations for variable message signs are LED displays. In recent years, some newer LED variable message signs have the ability to display coloured text and graphics. They are commonly installed on an overhead gantry structure or a cantilever structure. It is fully-programmable, customizable solution specific to the location for the benefit of users.

The information displayed is real-time dynamic information as well as static information controlled automatically via a central server. It is designed to affect motorist's behaviour to improve traffic flow and enhance the driving experience of motorists on roads.

The information displayed include:

- Live travel time between destinations
- Live traffic congestion
- Weather Updates
- Alternate routes
- Pollution data
- Variable Speed limits
- Event notice and motorist instructions
- Accident updates
- Incident management via Emergency messages
- Directional signs
- Traffic Do's and Don'ts
- Warning/Public messages etc.

Smart Variable Message signs should be able to draw information from cloud-based services as well as able to integrate with local road/ground-based sensors to provide information useful to the motorists. The variable message signs should be able to work on a standalone basis and show real-time information even in the event of a failure at the central server / during emergencies.

Unlike the late 1990s when the most common technology used in new installations for variable message signs is LED display which are mostly single colored displays showing static messages, today the technology has advanced and now these displays are fill colored with better resolution, capable of displaying both text and graphics as per IRC SP:110. A full-color 10 mm pitch LED display has a brightness of 7500-8000 cd/m^2 subject to availability of approval document from acceptable national/international approving authorities for better visibility and readability. These

Intelligent VMS boards shall have the facility to switch to Low Power mode screens in case of Mains power failure. Maximum Power consumption per cabinet should not exceed 400W/sq meter. These screens should be monitored remotely for pixel-level failure detection via a dashboard at the control room. It shall also provide Android-based application for Disaster Management and Emergency Messages. This solution proposed should support 128-bit encryption along with dongle based access control to ensure secure access and communications with the server.

Apart from Traffic management system, Variable Message Signs can be used at bus stops to display the live journey time of buses, can be integrated with other ITS solutions to give driver feedback, ensure driver safety and enforce traffic rules.

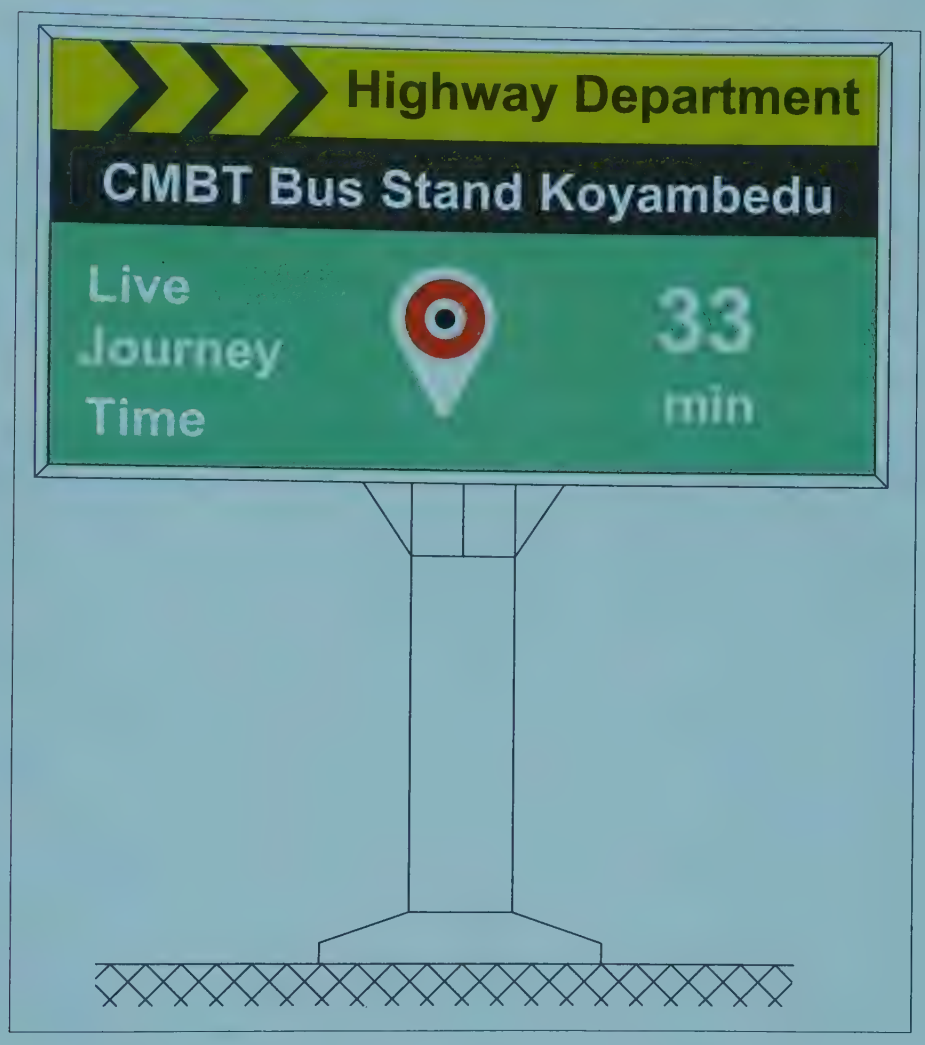


Fig. 10.4 Variable Message Signboard

10.4 Interactive Kiosks

Interactive Kiosks are computer-like terminals or larger machines that display travel information. These are generally found in malls, businesses, hotels, airports, and transit centers. Interactive kiosks are accessed easily using a computer mouse, touch screen, or keyboard. Kiosks can also deliver a wide range of travel information, like routes and schedules, traffic congestion, and weather, etc. When combined with automatic vehicle location information, kiosks provide the customers with real-time information, like on-time status of their transit vehicle.

10.5 Leaflets

Leaflets provide advance information about modifications and implementation of new traffic schemes—special arrangements on the eve of important festivals and public functions. Do's and don'ts of traffic safety; and other information of common public interest. These should be printed in different languages namely: English, Hindi and the local language (if different).

10.6 Periodical Press Notes

The press note should be issued at regular intervals through leading newspapers and magazines informing the public about the proposed traffic management plans. Enforcement drives, cautionary messages, accident statistics, and other useful traffic information that may be of interest to the public. All traffic regulations and changes must be made known to the public through such Press Notes. Senior officers should also give interviews to the press so that the public gets an insight about the not-so-obvious traffic aspects. It also elicits public opinion about various measures taken by the local authorities so that the administration gets the correct feedback to enable it to reconsider certain changes and effect necessary alterations if required.

10.7 TV and Radio Broadcast

T.V. and Radio are two very powerful media for reaching the public. TV interviews, panel discussions and road safety films. Radio broadcast on traffic related matters should be organised at frequent intervals in various languages. These two media can also be used for informing the public about various traffic management measures that become necessary on the eve of important events and major religious festivals.

10.8 Mobile Phone Application

Mobile Phone applications are growing rapidly and this is becoming easily accessible to the public. These devices are useful in transferring the traffic information dynamically. Mobile apps have become quite popular as these provide user interfaces that support easy access of information on mobile devices. There are various types and sizes of mobile devices in the market working on different Operating Systems (OS) such as iOS, Android, Windows. Hence mobile apps would need to be developed to support the desired device OS/device sizes. Delhi Traffic Police officials came up with an application for effective and instant communication through Mobile App which is provided in **Fig. 10.5**.

DELHI TRAFFIC POLICE
Register
FAQ
About Us
Privacy Statement
Disclaimer
DELHI TRAFFIC POLICE
Traffic Advisory
Traffic Alert
Taxi/Auto Fare
Complaints
Signal Fault
Towed Vehicles
Emergency Contacts
FAQ
Lost Report
DELHI TRAFFIC POLICE
TRAFFIC ADVISORY
IPL T-20 CRICKET MATCH AT FEROZESHAH KOTLA GROUND ON 07. 05. 2014
Indian Premier League IPL T-20 cricket match between Delhi Daredevils and Kolkata Night Riders, will be played at Ferozeshah Kotla Ground on 7th May 2014 from 4.00 p.m. to 08.00 p.m. Delhi Traffic Police has made elaborate traffic arrangements for traffic diversions and restrictions, parking of vehicles, traffic circulation, pedestrians' movement and safety of the visitors in and around the Stadium.
PARKING
There is very limited parking for labelled vehicles but no parking for general vehicles in the proximity of the Stadium.

Fig. 10.5 Traffic Mobile App (Delhi Traffic Police)

10.9 Greeting Cards

Greeting Cards with suitable traffic messages should be sent to important personalities, voluntary organizations, public representatives and political leaders, office bearers of various unions, members of the Press, eminent citizens and all those whose opinion matter in traffic management, on occasions such as New Year and other National days. These courtesies and decent gestures would earn the traffic authorities the appreciation and willing support of such persons.

10.10 Seminars and Talks

Social organisations, commercial groups, associations representing interest of road users, etc. should be encouraged to hold seminars, symposia, workshops and panel discussions as shown in **Fig. 10.6**. All proposed important traffic management schemes that are likely to have major impact on the movement of various road users can be discussed threadbare so that the benefits that are likely to accrue get highlighted and apprehensions of the public, if any are removed. It would also help in getting an objective feedback so that the authorities may consider various suggestions and effect appropriate modifications if so required.

सड़क और वाहन अभियांत्रिकी विषय पर कार्यशाला
Workshop on Road and Vehicle Engineering
श्री नितिन गडकरी
Sh. Nitin Gadkari
Ministry of Road Transport and Highways, Govt. of India

Fig. 10.6 Seminars and Talks

10.11 Committees

Various committees representing interests of different road users should be formed so that all sections of road users feel that their interests are being safeguarded by their representatives. Regular meetings should also be held with the representatives of various unions of taxi men, transport operators, auto-rickshaws, etc. Special consultative committees should be formed to deal with the specific issues, as it helps in bringing members, representing divergent interests, across the table to appreciate various pros and cons of any important traffic management scheme.

10.12 Students Participation

The students should be actively involved in traffic discipline and road safety so that an era of

traffic culture can be ushered in. The authorities should encourage 'Road Safety Patrol' (RSP) activities in all schools covering children of the age group of 9-14 as shown in **Fig. 10.7**. Traffic officers should visit such schools and impart them in traffic education. They should be shown traffic safety films and guided about various do's and don'ts on the road. Outdoor activities like Road Safety Weeks, Fuel Conservation Weeks, RSP Camps. etc. should be periodically organized, besides holding essay, painting, slogan and quiz contests on traffic subjects, to stimulate the young ones thinking on this vital aspect of life. The services of these children should also be used during important bandobasts to supplement traffic manpower.

It is equally necessary to involve college students in similar activities for promoting road safety. They can also help the traffic police in disciplining the pedestrians, other road users and controlling the bus queues, etc.

In the literature researchers were reviewed the effect of safety promotions, and the studies suggested that the effective education programmes includes education of professional and policy makers, information about new safety products, programmes in support of new laws, and infrastructure design.

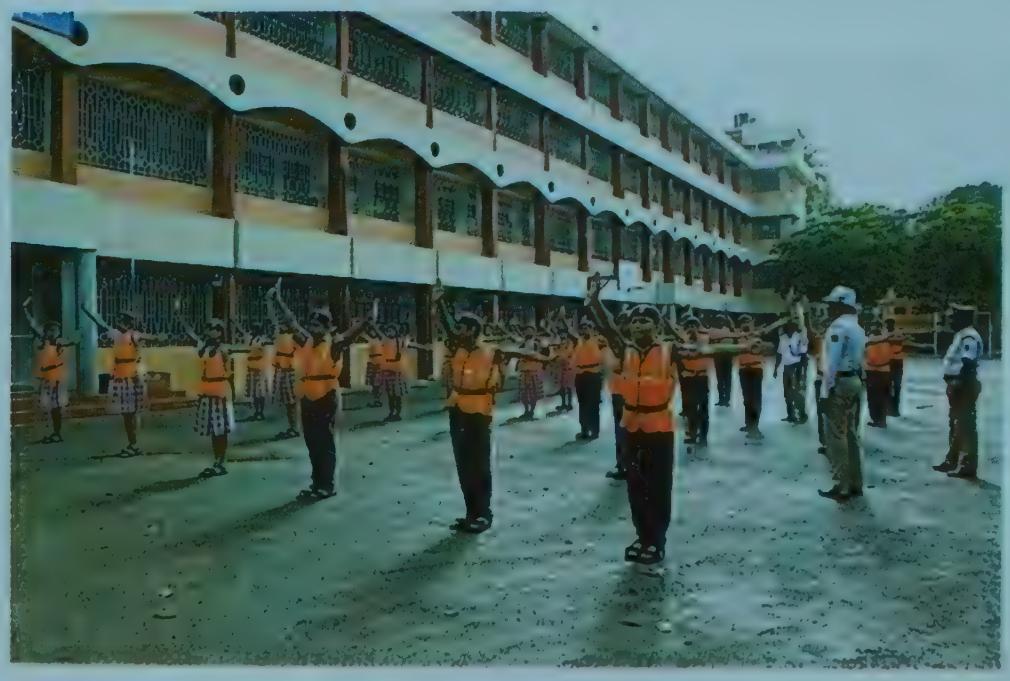


Fig. 10.7 Road Safety Patrol

10.13 Traffic Warden Scheme

It is equally necessary to seek community participation in traffic control and road safety. Volunteers amongst the public should be intelligently selected so that the undesirable elements do not enter the ranks. Such volunteers should be imparted special training and then inducted as traffic wardens. They can help in controlling traffic at intersections, disciplining the pedestrians, and noting down traffic violations. Periodical review meetings should be held with them. However, a close watch on their working is necessary to make sure that no one takes undue advantage of these powers. (**Fig. 10.8**)

Fig. 10.8 Traffic Warden Scheme

10.14 Traffic Exhibitions

The authorities should prepare interesting audio-visual displays, electronic games, etc. to convey traffic messages more effectively. They should hold exhibitions with these displays and screen road safety films at different places to educate the common man (**Fig. 10.9**).

Fig. 10.9 Traffic Exhibitions

10.15 Traffic Parks

Children parks should be created to inject traffic awareness amongst school children through 'play & team games'. Such parks teach the children as to how they should make use of the roads as motorists, cyclists as well as pedestrians. **Fig. 10.10** shows some profile of such parks.

Fig. 10.10 Traffic Parks

10.16 Traffic Booths/Aid Post

Small cabins should be installed at important locations such as railway stations, airports, bus terminals, and other important areas so that Traffic Police can provide general assistance to the public in terms of information, first-aid, communication, etc. These booths should display useful information about hospitals, airlines and train timings, hotels, etc. to enhance the image of the Traffic Department as good Samaritans. They also provide a nucleus and field base for the traffic personnel deployed in a particular area. One such booth is shown in **Fig. 10.11**.

Fig. 10.11 Traffic Booths

10.17 Public Display System

Public displays increasingly find their way into public space and offer a wide range of information to the user. Currently, most of these displays just represent information without the chance to explore them or interact with them. In general, by technical enhancements in this field, more and more possibilities of interaction are given in different domains. This work presents interaction opportunities between public displays and users with mobile devices in the field of public transport. As a basis for understanding the usage and benefits of public displays, it is necessary to have a closer look at different types of displays in the public domain, too.

In general, digital signage is a networked (audio) visual information system. The content can be digitally created, managed, and played anywhere on a digital device. For this purpose, information is provided by people, but also by sensors and databases (**Fig. 10.12** information delivery). A Content Management System (CMS) running on a server allows an organized information representation on displays. There is the possibility to control single monitors directly or combining several screens into logical groups (**Fig. 10.12** information presentation). The content can also be presented independently, to constantly communicate the relevant information (**Fig. 10.12**) information assignment). While digital signage is a distributed system, a public display represents only an end device which shows digital content. Therefore, a public display can be seen as a part of digital signage.

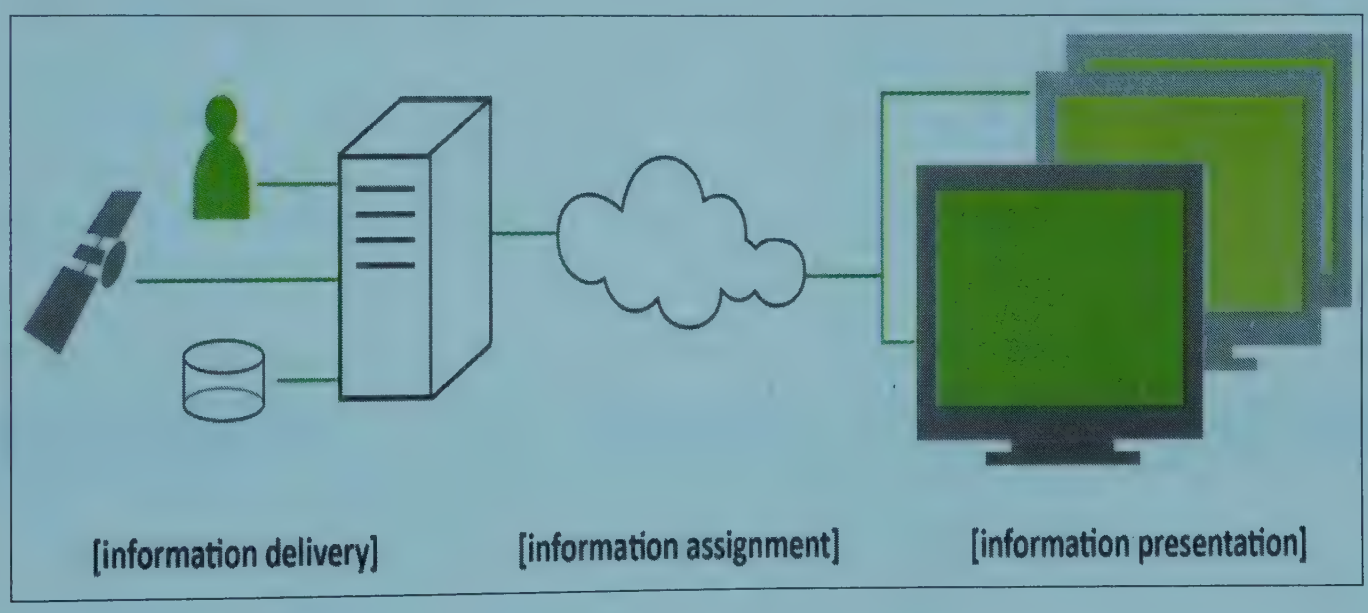


Fig. 10.12 Schematic Construction of a Public Display System

10.18 Bus Stops

One reason that advertising has seen such success in public transport areas is that, as with any kind of public transportation, people making trips have to wait. Bus shelters can provide billboards and interactive screens. On the tube underground there is a huge amount of wall space, as well as inside the trains, to display screens showing information and advertising, Taxis can show content usually advertising on screens on the top of taxis. **(Fig. 10.13)**

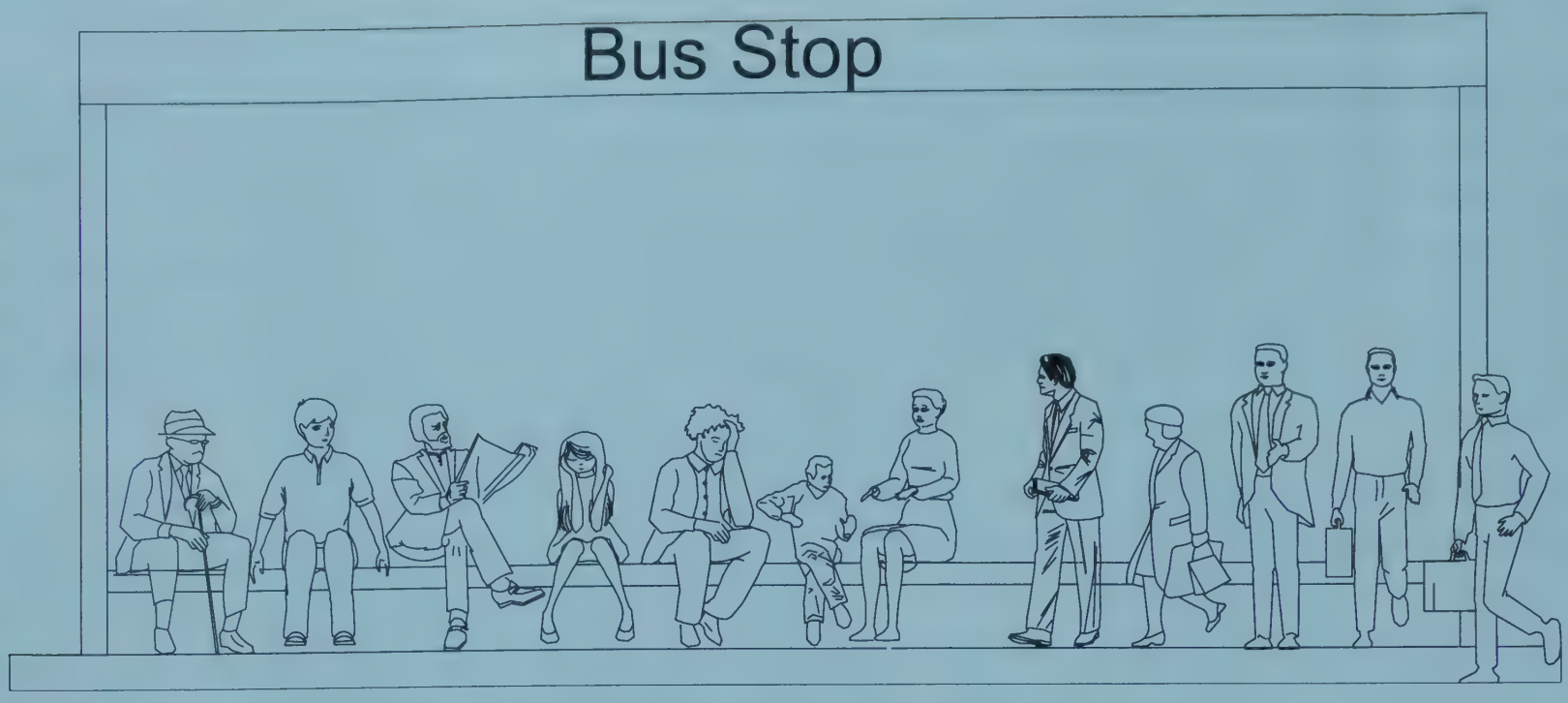


Fig. 10.13 Waiting Area of Public Transit

10.19 Social Media

Social media (Face book, Twitter, etc.) should also be used as an information dissemination channel for certain types of information such as traffic updates, alerts, events, road diversions/ closures, incidents, accidents, etc. Traffic Police Facebook or Twitter handle may help save time as police are all set to go live on social media **(Fig. 10.14)**. Online teams will also interact with the public to spread traffic jams. Cops may take the help of Google Maps that show the level of congestion and suggests better routes. The use of social media platforms like hashtags on Instagram and the post of Facebook can be used for effective management and governance. **(Fig 10.14).**

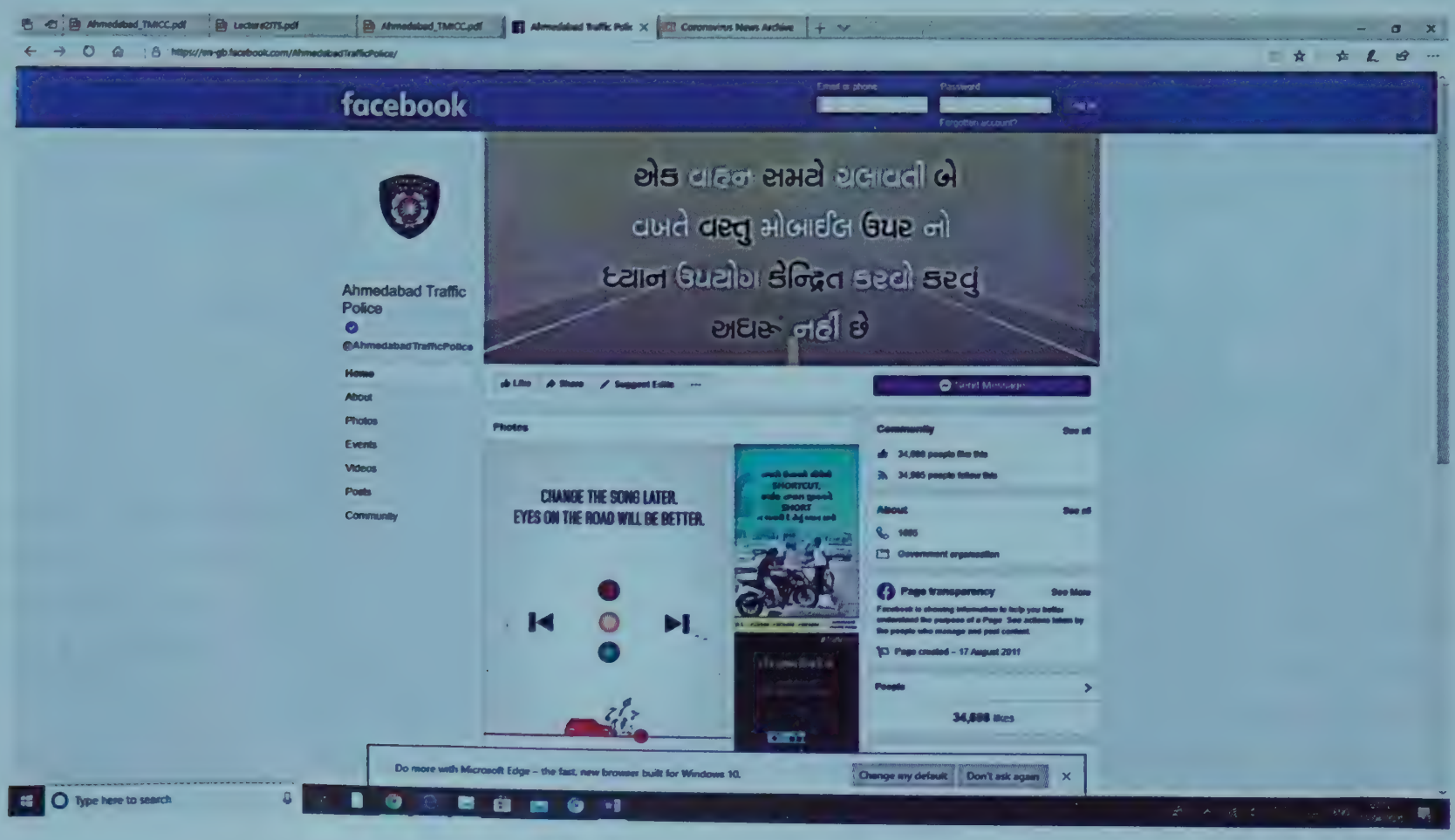


Fig. 10.14 Ahmedabad City Traffic Police Facebook Page

10.20 Online Navigation

Online navigation is most widely used in finding locations. It also helps us in seeing our regular commute information. We can see the delays and the type of traffic in particular areas. These are also the best public interaction techniques that are widely used by several people all over the world. One of the widely used online navigation is Google Traffic, which is a feature on Google Maps (Google Maps) that displays traffic conditions in real-time on major roads and highways. By using the choose view menu in the Google maps, this will display traffic conditions, roadblocks, traffic incidents, satellite maps, terrain maps, and public transport details (**Fig. 10.15**). The colored lines representing traffic conditions on major highways or streets refer to the speed at which one can travel on that road. The Yellow lines on the map mean highway traffic is moving with slow speed, Blue lines on the map indicate that traffic is moving faster, the Red line on the map indicates extremely slow or stopped traffic.

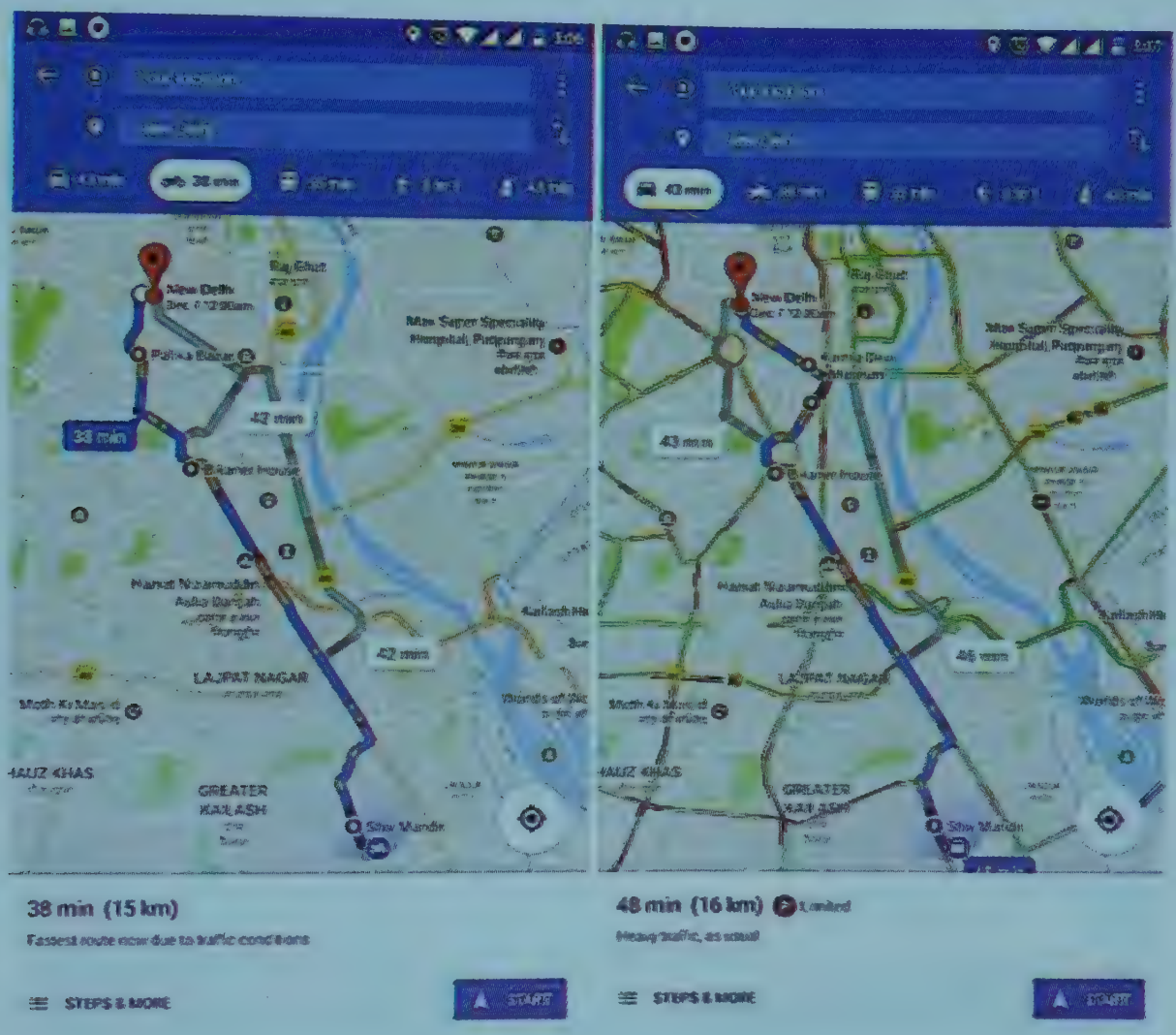


Fig. 10.15 Online Navigation

10.21 Road Safety Audit Programmes

n India, various organizations are conducting long term (more than two weeks) and short term one week) safety audit training programs for civil engineers and policymakers. The organizations, ke Central Road Research Institute (CRRI), Indian Academy of Highway Engineers(IAHE) are rganising long term road safety audit programs. Various academic institutes (IITs, NITs etc) rganizing one week safety audit training programs to research scholars, engineers, and policy nakers.

11. ITS TOOL FOR TRAFFIC MANAGEMENT

11.1 Role of ITS

Intelligent Transportation System (ITS) is the application of computer, electronics, and communication technologies and management strategies in an integrated manner to provide traveler knowledge to extend the safety and efficiency of the surface transportation systems. ITS have evolved with applications, as well as collision warning systems, advanced signal control systems, transit and emergency vehicle management systems, and others.

11.2 Advanced Traffic Management System (ATMS)

The ATMS view is a top-down management perspective that integrates technology primarily to improve the flow of vehicles and safety. Real-time traffic data from cameras, speed sensors, etc. traffic flows with respect to passenger and goods vehicles into a Transportation Management Centre (TMC) where it is integrated and processed (e.g. for incident detection), and may result in actions taken (e.g. traffic routing, dynamic messages) with the goal of improving traffic flow. This service deals with the issue related to road network-based traffic management. ATMS provides the most economic benefits to the traffic management of the city. Most of the cities are adopting ATMS in three-level namely strategic levels (for traffic management system), tactical level (for guidance and traffic control), and operational level (Cameras and detectors at intersections). Merging of traffic information and traffic management can be possible by ATMS. **Fig. 11.1** shows the integration of traffic information and management capabilities.

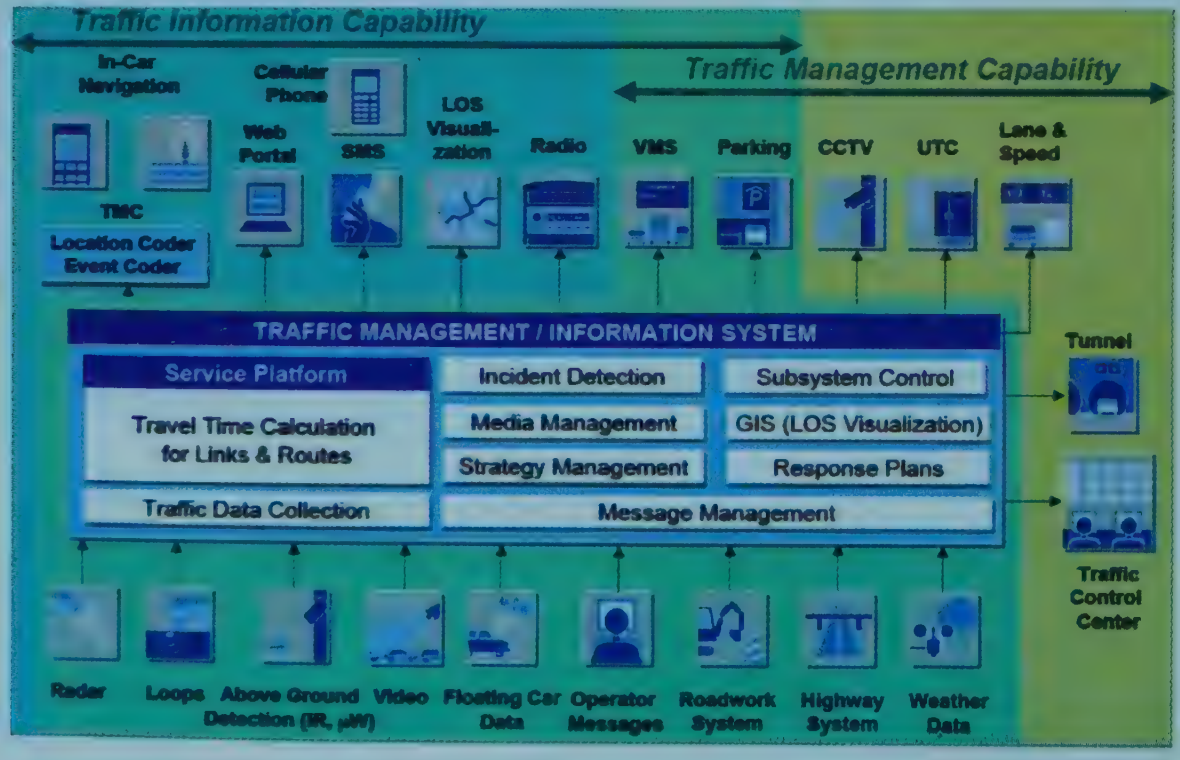


Fig. 11.1 Capability of Integrating Traffic Information and Traffic Management

11.3 Traffic Management Centre (TMC)

TMC is the hub of transport administration, where data is collected and analyzed and combined with other operational and control concepts to manage the complex transport management

network. It is the focal point for communicating transportation-related information to the media and the motoring public, a place where agencies can coordinate their responses to transportation situations and conditions. Typically, several agencies share the administration of transport infrastructure through a network of traffic operation and management centers. There is a localized distribution of data and information, communication with traffic management centers which adopts different criteria to achieve the goals of traffic management. This inter-dependent autonomy in operations and decision-making is essential because of the heterogeneity of demand and performance characteristics of interacting subsystems. In India cloud-based integrated control and command center was established **(Fig. 11.2)**. This was established under the smart city program by Bhopal Smart City Development Corporation Ltd. This will enable the Madhya Pradesh state administration to monitor and administer multiple city civic utilities and citizen services across seven cities in the state through a central cloud. The Integrated Control and Command Centers (ICCC) will Integrate IT systems of different stakeholders to enhance safety, security, and providing better public services in the cities.

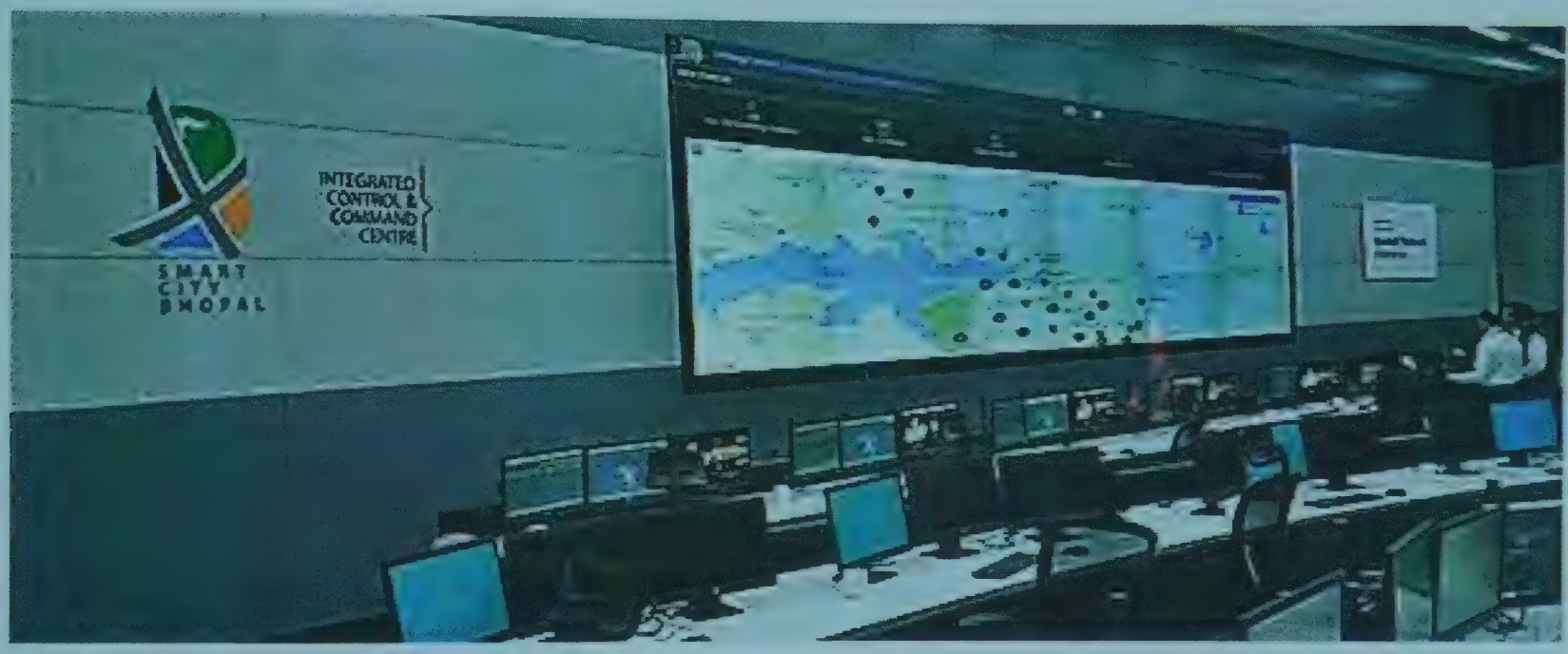


Fig. 11.2 Integrated Control and Center (BSCDCL) Bhopal

When it is not possible to develop a comprehensive Traffic Management Control Centre due to paucity of funds, traffic management measures for a single location or for a set of locations are commonly provided with ANPR, Red Light Camera, Speed/Detection/Enforcement Camera, Variable Message Signs (VMS) in urban areas (IRC:SP:110).

11.4 ITS TOOLS FOR SAFETY

The objective of the transportation system is to improve seamless travel with safety. Crashes and fatalities are the undesirable occurrences of the transportation system. Intelligent Transportation System helps to minimize the risk of occurrences of an accident. IRC:SP:110 "Application of Intelligent Transport System for Urban Roads" discussed various speed violation detection techniques. Some of the systems related to safety is briefly discussed.

Advanced Vehicle Control & Safety Systems: The user service aims to improve the safety of the transportation system by improving the drivers' abilities with respect to maintaining vigilance and control of the vehicle through enhancing the accident avoidance capabilities of vehicles. Following user services are included in this group:

Longitudinal Collision Avoidance: The user service can assist vehicle operators in avoiding collisions to the front and/or rear of the vehicle longitudinally. This is achieved by implementing rear-end collision control and warning, Adaptive Cruise Control (ACC), head-on collision control and warning, and backing collision warning to the drivers.

Lateral Collision Avoidance: This helps drivers in avoiding accidents that result when a vehicle goes out of a lane of travel, by warning drivers and by assuming some control of the vehicle. This service assists the drivers through the blind spot situation display/lane change, lane departure warning and control, and collision warning control.

Intersection Collision Avoidance: The aim is to assist the vehicle operators in avoiding collisions at intersections. With this system, the position of vehicles within the intersection area through the use of vehicle-to-vehicle communications or vehicle to infrastructure communications can be tracked.

Vision Enhancement for Crash Avoidance: This service helps in reducing the number of a vehicle accident that occurs during periods of poor visibility. Vehicle sensors capable of capturing an image of a driving environment and providing a graphical display of the image help the drivers to enhance road safety.

Safety Readiness: With the help of this, warnings regarding their own driving performance, the condition of the vehicle, and the condition of the roadway as sensed from the vehicle can be provided to drivers.

Pre-Crash Restraint Deployment: This service helps in reducing the number and severity of injuries caused by vehicle collisions by anticipating an imminent collision and by activating passenger safety systems prior to the actual impact.

Automated Vehicle Operations (AVO): This service provides a fully automatic vehicle-highway system in which instrumented vehicles operate on instrumented roadways without operator intervention.

ITS Application on improving Vulnerable Road Safety: The European Union has prioritized ITS applications which have a potential to improve the safety, mobility and comfort of Vulnerable Road Users (VRUs) and performed a quantitative safety, mobility and comfort assessment for the 10 most promising systems. The 10 selected ITS were: VRU beacon system, Powered Two Wheelers oncoming Vehicle information, Bicycle-to-Vehicle communication, Cooperative Intersection safety, Green wave for cyclists, Pedestrian & Cyclist detection with Emergency Braking, Blind spot detection, Intelligent pedestrian traffic signal, Crossing adaptive lighting and Information on bike rack vacancy. The development of an architecture for the integration of Vulnerable Road Users (VRUs), i.e. pedestrians, cyclists and powered two-wheelers (PTWs) in Cooperative ITS (C-ITS) systems, and the requirements for VRU devices. C-ITS technologies allow to communicate with low latency in highly dynamic environments. C-ITS will be integrated in vehicles and can also become available for VRUs, either as an application on a smartphone or as a dedicated device, which can be integrated in the VRU's vehicle (Scholliers, et al. 2017)

11.5 Emergency Vehicle Management (EVM)

The EVM service will provide for more efficient management and assignment of emergency response vehicles. Its intent is to reduce the amount of time between a public safety operator's notification of an incident and the arrival of emergency personnel on the accident location. This service will provide public safety agencies with fleet-management capabilities, route guidance, and signal priority and pre-arrangement for emergency vehicles.

This service consists of three subdivisions:

- Emergency vehicle fleet management
- Route guidance
- Signal priority

The primary users of all these services are police, fire, and hospitals. Real-time reliable transportation and traffic information is required by this service to provide travel alternatives for the arrival of the emergency vehicle at the emergency site; location of the incident and of emergency vehicles in the fleet is essential at the dispatch center. Emergency Vehicle Management will identify the closest and most appropriate response vehicle, and transfer complete, accurate information on the nature and location of the incident to it.

Performance requirements developed to date indicate that EVM should provide real-time emergency vehicle fleet management, offer vehicle identification with 99.9% accuracy within one minute of initiation, and vehicle location with position accuracy within the range of 6-15 m. The system should also provide real-time traffic signal prioritization by maintaining current information on signal timing, vehicle's location which is in an emergency, and its routing.

Traffic Management at Bottle Neck Points: It is important to learn more about the behavior of bottlenecks and the spatial extent of queues. The game in congestion management is queue avoidance and containment. This can be achieved through a combination of active control measures such as ramp metering and also by means of passive measures such as route guidance and information delivery.

11.6 Traffic Simulation Techniques

Micro simulation based traffic simulation techniques useful to evaluate the performance of proposed traffic management measures before implementation on ground. Micro-simulation techniques useful to analyses individual vehicle behavior more precisely and realistically than the macroscopic approach (Travel demand models). The main input parameters for development simulation models are includes road geometry details, traffic flow and composition, desired speed distribution of vehicles, vehicle parameters, acceleration and deceleration rates of vehicles and signal control parameters (phasing and timing) and driver behavior parameters namely car-following and lane change behavior. Most of the simulation model available in the literatures needs to validate for the Indian mixed traffic conditions before implementing of proposed policy measures. The methodology to evaluate traffic management issues at network level or corridor level through simulation techniques is discussed at **Fig. 11.3.**

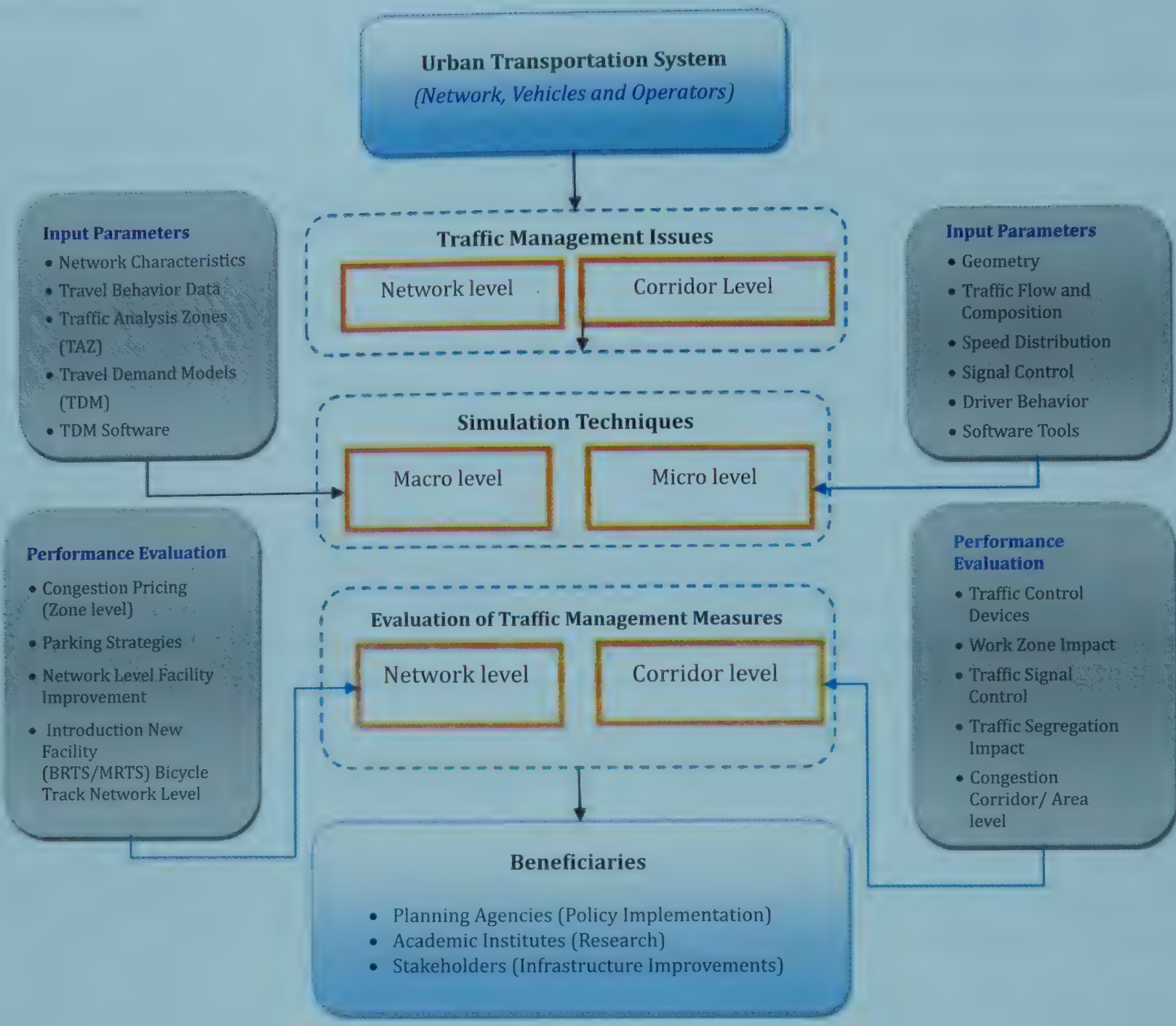


Fig. 11.3 Methodology to evaluate Traffic Management Issues through Simulation Techniques

12. INSTITUTIONAL COORDINATION AND CITIZENS COOPERATIONS

The traffic control and management involve three components viz. road, vehicle, and road user. It is, therefore, the joint responsibility of all the organizations responsible for its operating environment. Unless all the concerned organisations interact with each other and coordinate their efforts, the traffic police and traffic engineers alone cannot successfully meet the ever-growing challenges thrown by the urban traffic and transportation problems. The Ministry of Housing and Urban Affairs (MOHUA) National Urban Transport Policy (2006) recommended that each city of more than a million residents form an Urban Metropolitan Transport Authority (UMTA). Only a few cities acted on the recommendation. In India, most of the cities under smart city vision have adopted IT-based traffic management system to bring efficiencies in managing traffic at the network level within their cities. Ministry of Urban Development, Government of India, published operation document for Traffic Management and Information Control Center (MoUD, 2016). This operational manual suggested the responsibilities of various city agencies during the implementation and operations of TMICC.

12.1 Institutional Coordination

The following three major areas, in particular, require good coordination between various utilities.

12.1.1 *Roads*

The local Municipal Corporation/PWD must ensure good maintenance of all roads and footpaths, including channelisers at intersections. All safety measures should conform to the Indian Roads Congress (IRC) standards and must be maintained well. A good street lighting system in urban areas can be very effective in reducing accidents. Concrete and mastic surface provide better riding quality and have a longer life.

12.1.2 *Road-Side Frictions*

The road-side frictions, especially activities on the roadside, reduce the road capacity, for example, the encroachment of footpaths forcing pedestrians to use main carriageways. The other examples are dumping of construction material and garbage on roads/footpaths, poor location of manholes, erection of a large number of poles, other installations like junction boxes, traffic sign-boards, manhole chambers, etc., huge hoardings and other protruding structures on the roadside. There are many other encroachments like street vendors, pavement dwellers, beggars, and squatting of animals. etc. which not only constrict the vehicular movement but also result in inevitable conflicts, but also impede the smooth and safe flow of pedestrians.

It is, therefore, essential to formulate certain policies and guidelines for regulating the aforementioned road-side frictions. Joint action by the local municipal bodies and police can help bring about better discipline. A joint survey can also be arranged by the concerned departments to see how various poles on roads and footpaths can be put to multipurpose usage. For instance, no parking sign-boards can be fixed on electric/telephone poles along footpath wherever possible. Such surveys can help reduce the street furniture and thus improve the movement on roads and footpaths.

12.1.3 *Excavations and Work Zones*

A large number of excavations are regularly undertaken by various utilities like the water, sewerage, road maintenance department, telecommunication and electric supply departments, gas authority, etc. Unless these excavations are appropriately coordinated with respect to space and time, they can cause serious traffic disruptions. As such excavations are not normally taken during the monsoon, it would be desirable not to plan any such excavations which have to be inevitably carried out during the monsoon time. The traffic police can coordinate and monitor so that minimum inconvenience is caused to the road users.

The road work zones are areas of conflict between normal operating traffic, construction workers, road building machinery and construction traffic. To ensure the safety of all the road users, there is a need to adopt an efficient and effective plan for the management of traffic in work zones. Work Zones Traffic Management Plans (WTMPs) are required to meet the safety needs of regular traffic as well as ensuring a minimum disruption in access to properties and movement of pedestrians. For details refer IRC:SP:55 Guidelines for Traffic Management in Work Zones. Local police shall provide all the required support for the enforcement of the necessary restrictions, if imposed, and for the safety measures as warranted by WTMP. The control for speeding and careless driving in work zones should be strictly enforced.

12.2 Enforcement

Besides the aforementioned three areas, good enforcement of rules and effective checking of violations by the traffic police can play an important role in improving the carrying capacity of the carriageway. However, a very vital aspect of the enforcement is the manner in which individual officers and constables behave while enforcing traffic laws in general, and new traffic schemes in particular. The experience usually makes a long-lasting impression on the person concerned, who describes it to his family, to his friends and, business acquaintances. It is the aggregate of such impressions which largely makes public opinion. It is, therefore, very important to ensure that in enforcing the law, the goodwill of the public is not forfeited. Thus, it is very essential to impart good education to the officers in the field in "Public Relations".

While cooperation between the public and the police is of utmost value, it can only be based upon mutual respect and understanding as well as complete recognition and acceptance on both sides. There can be no proper cooperation on the part of the police.

Promote the use of ITS technology for regulatory enforcement, using integrated databases for tracking traffic violations with driving licenses, and data capture tools such as video analytics, sensors, and other solutions for automated enforcement. Strict enforcement rules are necessary for safer roads for all users. Traffic Management and Information Control Center (TMICC) has been set up by integrating various components of road marking, signages, Enforcement Cameras, Surveillance Cameras, and up-gradation of Signals including Vehicle Actuation for effective and efficient management of traffic **(Fig. 12.1)**. Traffic enforcement should be considered as part of the planning process, and emergency service providers should be consulted when developing the plan. In certain instances, TMICC may also use the video feeds available through the enforcement system to cross-check or validate traffic-related issues which have been reported to the TMICC (MoUD, 2016). Accident data and management is a vital aspect to evaluate the safety scenario in urban areas. The geo-spatial data utilization to develop hotspot map of accidents can be recommended as a mandatory practice under Traffic Police.

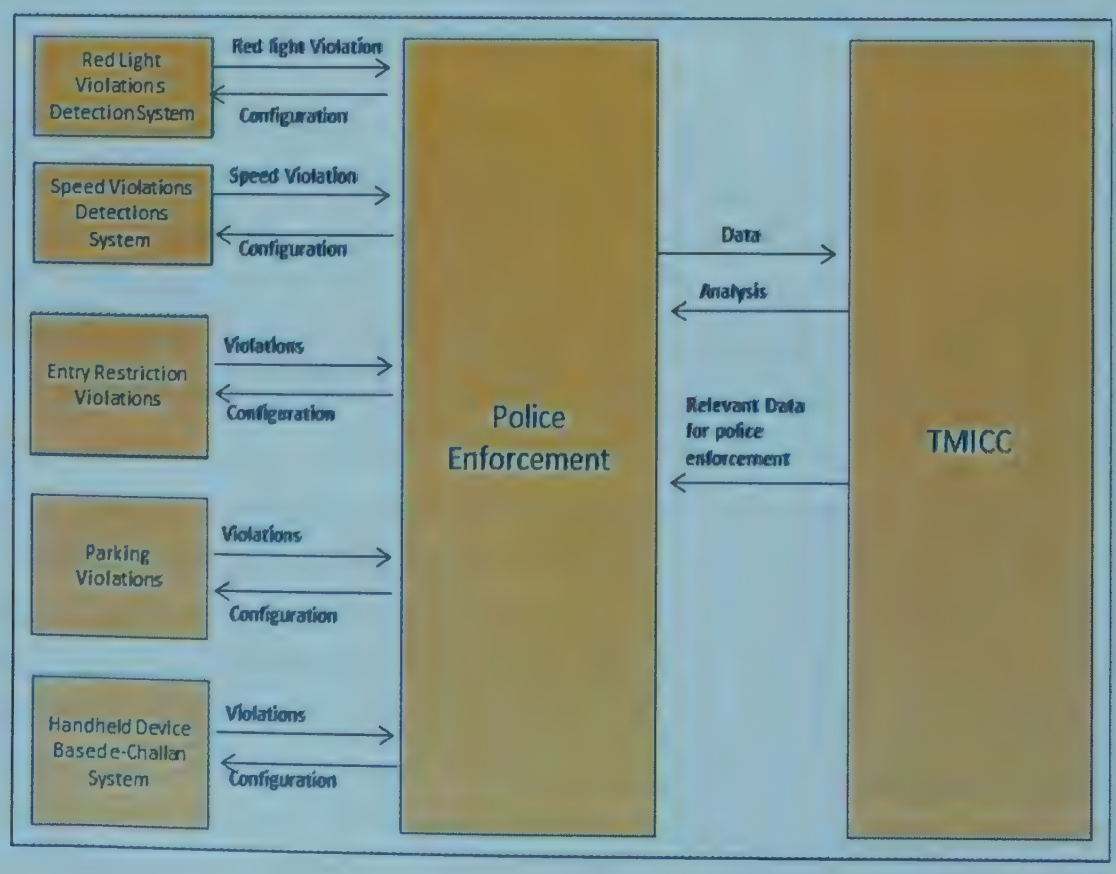


Fig. 12.1 Traffic Enforcement using TMICC (MouD, 2016)

12.3 Citizen's Participation

While effective resource-utilization by judicious application of traffic management techniques, well researched ITS technology to update the existing transportation facilities, and information technology used to forecast the transportation needs to work out various alternatives, may well be the present-day traffic manager's panacea for maximizing the level of service and satisfaction, the one variable that can throw even the best traffic management plan into disarray is the lack of the citizen's confidence.

A change unilaterally imposed is most likely to be opposed. It is, therefore, unwise to initiate any new measures of traffic regulation and enforcement without adequate preparation to ensure some measure of public understanding and some degree of public acceptance. In reality, public participation in traffic management falls woefully short. The reasons are not too far to seek. Urban society is no longer the homogeneous community as it used to be. A vast change in its basic structure has been brought about due to mass exodus from rural areas. The new immigrant is an alien in the urban environment. The pressures of daily life in his changed circumstances keep him involved with his personal problems. He has neither the energy nor any inclination to involve himself in community matters. The resident, on the other hand, views every administrative change as an intrusion into his traditional life and is not kindly disposed towards any such changes. The administration thus is often caught between the unconcern of one section and the apprehension of the other, making the task of the traffic manager very arduous. With the public responding more positively, he can produce solutions from various alternatives that will generally be acceptable to both sections of the society and that are in consonance with the government policies.

The success of any traffic management scheme rests on the pivots of public participation and institutional coordination. The lowest cost traffic management techniques, therefore, aim to win the confidence of the road user and enhance the credibility of the administration through the coordinated efforts of various public agencies involved in the traffic and transportation management. Even if adequate funds are not available for the implementation of various schemes, these efforts will generate a lot of public goodwill and ensure their voluntary cooperation in making the authorities' task easier.

Road authorities should plan and set up the system for informing the users regarding traffic management techniques through print, electronic, and social media. Citizen participation and dissemination of information through smart phone call are significantly useful. Most of the smartphones are these days are location-enabled. Combined with social media applications such as Facebook and Twitter, citizens play a significant role in how such devices report and record information.

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